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Forest Service

Forest Pest
Management

Davis, CA

ANALYSIS OF THE USDA FOREST SERVICE 1988 AIRCRAFT SPRAY CHARACTERIZATION TRIALS

aSB953
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1992

FPM 93-5
December 1992

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Pesticides used improperly can be injurious to human beings, animals, and plants. Follow the directions and heed all precautions on labels. Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides where there is danger of drift when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment, if specified on the label.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S. Environmental Protection Agency, consult your local forest pathologist, county agriculture agent, or State extension specialist to be sure the intended use is still registered.



FPM 93-5
December 1992

Analysis of the
USDA Forest Service
1988 Aircraft Spray
Characterization Trials

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PREFACE

The analyses presented in this report was funded by the USDA Forest Service, Forest Pest Management, Davis, CA. Data for analyses was collected by the Forest Service (Barry, Warner, and Skyler, 1988).

These trials were made possible through the cooperation of Growers Air Service, Evergreen Helicopters, Eldorado National Forest, Nez Perce National Forest, Missoula Technology Development Center, and Forest Pest Management staff from the Pacific Southwest and Pacific Northwest Region.

INTRODUCTION

This is a report on the aircraft spray characterization trials conducted near Davis, California, 14 - 19 March 1988 by the USDA Forest Service, Forest Pest Management. This report compares results of four different sampling procedures.

These four sampling procedures consisted of Kromekote™ paper placed: 1) horizontally at ground level; 2) on top of wood stakes; 3) vertically on the north; and 4) vertically on the south sides of wood stakes.

Data concerning the effective swath width are illustrated by bar charts including the formulations used, mean deposition of droplets in swath width, aircraft and atomizer, and the weather conditions during trial. A series of scattergram plots are also included to show the various deposition patterns for both swath width and mean deposition as a function of the weather parameters.

In the conduct of airport or aircraft spray characterization trials the aim is to collect spray drops which would be presented to the top of the canopy under operational conditions (Dumbauld and Rafferty, 1977). A ground-based spray deposit card line represents a theoretical sampling line stretched across canopy top.

Studies have shown that a 4.5 m/s (10 mph) wind 2-meters above the card line would equate to a 1.1 m/s (2.5 mph) wind at a forest canopy top and an 8.0 m/s (18 mph) wind would equate to a 2.0 m/s (4.5 mph) wind (Figure 1; Silversides, 1978). These are important considerations in conducting airport trials for ultra-low volume (ULV) compared to low-volume (LV) and high volume (HV) applications. The premise that low wind conditions are ideal for LV and HV does not hold for ULV. Spraying under higher winds is especially important to successful ULV spraying. Small drops collect more efficiently on coniferous foliage if propelled by wind and turbulence. On the other hand, lacking these forces they tend to move with air currents rather than collecting on the target.

OBJECTIVES

The objectives of this study and analysis were:

- 1) To study pesticide deposits on collectors placed at different heights and orientations relative to the flight path; and
- 2) Develop recommendations for standard placement of collectors in aircraft characterization tests.

METHODOLOGY

A total of 44 aircraft spray characterization data trials were completed at Growers Air Service, Woodland, CA, 14-19 March 1988. Product, formulation, aircraft, and atomizers used are detailed in Table 1. The purpose of the trials was to observe the atomization of four undiluted

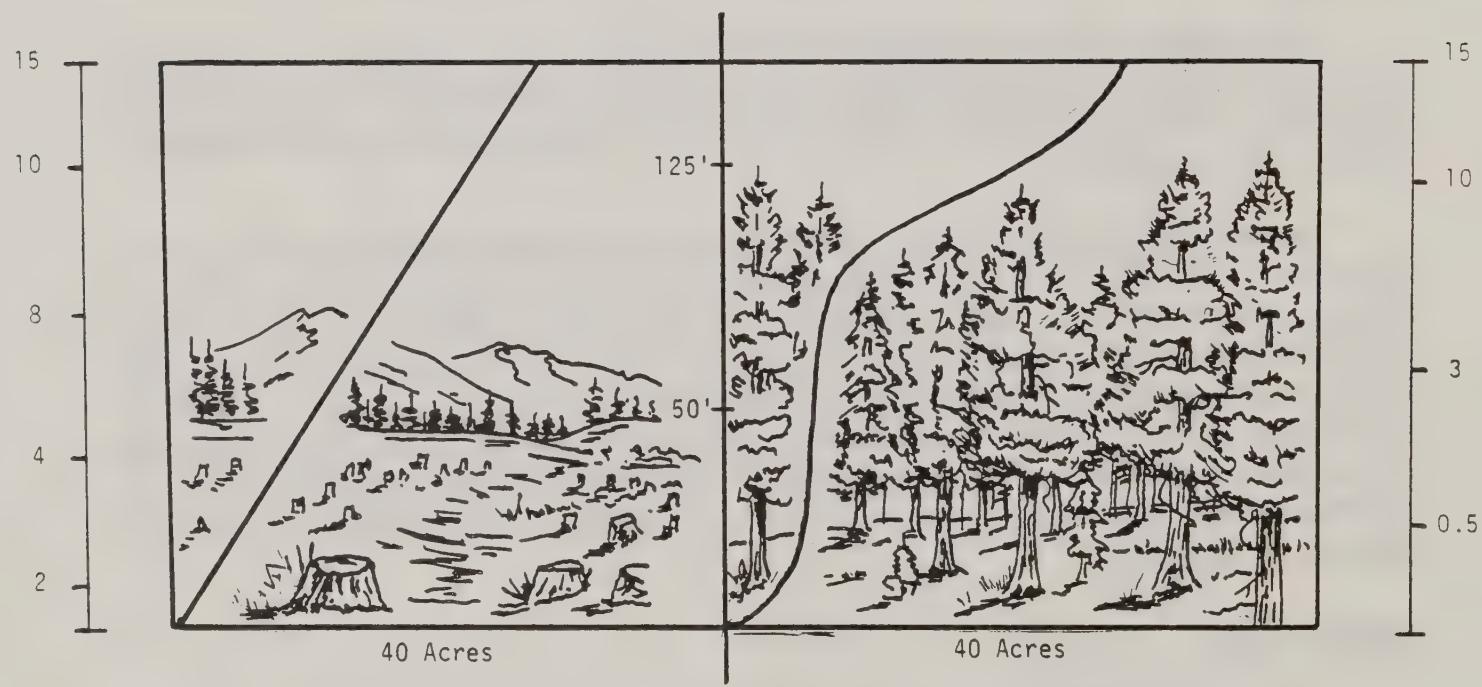


Figure 1. Relationship of wind speed at center of clearings to inside edge of forest as a function of height (from Silversides, 1978)

formulations in preparation for the USDA Forest Service (FS) 1988 operational program to control western spruce budworm in Oregon (Barry, Warner, and Skyler, 1988). Specifically there was a need to identify any potential problems in the spraying and atomization of these formulations. The trials provided an opportunity to evaluate potential differences in spray recoveries that might result between the four possible Kromekote™ card positions relative to the spray application.

Table 1. Product, formulation, aircraft, and atomizer combinations tested.

Formulation	Number of Trials	Aircraft	Atomizer
Dipel 6L	6	Air Tractor 301	Micronair AU4000
	3	Bell 205A1	Beecomist 360A
	4	Bell 205A1	Micronair AU5000
Dipel 6AF	4	Bell 205A1	Beecomist 360A
	10	Air Tractor 301	Micronair AU4000
Thuricide 48LV	5	Bell 205A1	Beecomist 360A
	3	Air Tractor 301	Micronair AU4000
Thuricide 32LV	2	Bell 205A1	Beecomist 360A
	7	Air Tractor 301	Micronair AU4000

Formulated products were provided by the manufacturers and aircraft were contracted by FS. Field assistance was provided by personnel from Abbott Laboratories, Sandoz Crop Protection, and FS. Field trials, data collection, and initial data analysis were conducted by FS.

FSCBG model runs were conducted before field trials to estimate swath widths for each aircraft. Results are reported by Skyler, Barry, and Warner (1989).

Aircraft were configured as depicted in Figures 2, 3, 4, and 5.

A southwest to northeast spray deposit sample line was established in a field that had been recently plowed and furrowed. Kromekote™ samplers were placed at 3 meter (10 foot) intervals along the 150 meter (500 foot) line (Figure 6). Each of the 50 positions contained a Kromekote™ card positioned horizontally on the ground and a 5.7 x 20.8 cm (2 1/4 x 8 3/16 inches) Kromekote™ strip placed over a 2.5 x 2.5 cm (2 x 2 inch) stake. The strip was secured over the 30.5 cm (12 inch) high stake top with two equal vertical surface areas on the north and south side of the stake. Additionally Douglas fir foliage was secured to the top of the 30.5 cm (12 inch) stakes at positions 10, 15, 20, 25, 30, 35, and 40.

On each trial the aircraft flew over the mid-section of the cardline into the wind (Figure 6). The aircraft was offset west or east of center to allow for variation in wind direction. This was intended to contain the spray swath within the cardline. In most trials, but not all, the deposits were contained within the cardline. The aircraft sprayed a distance of approximately 1 kilometer (0.6 mile) on each trial.

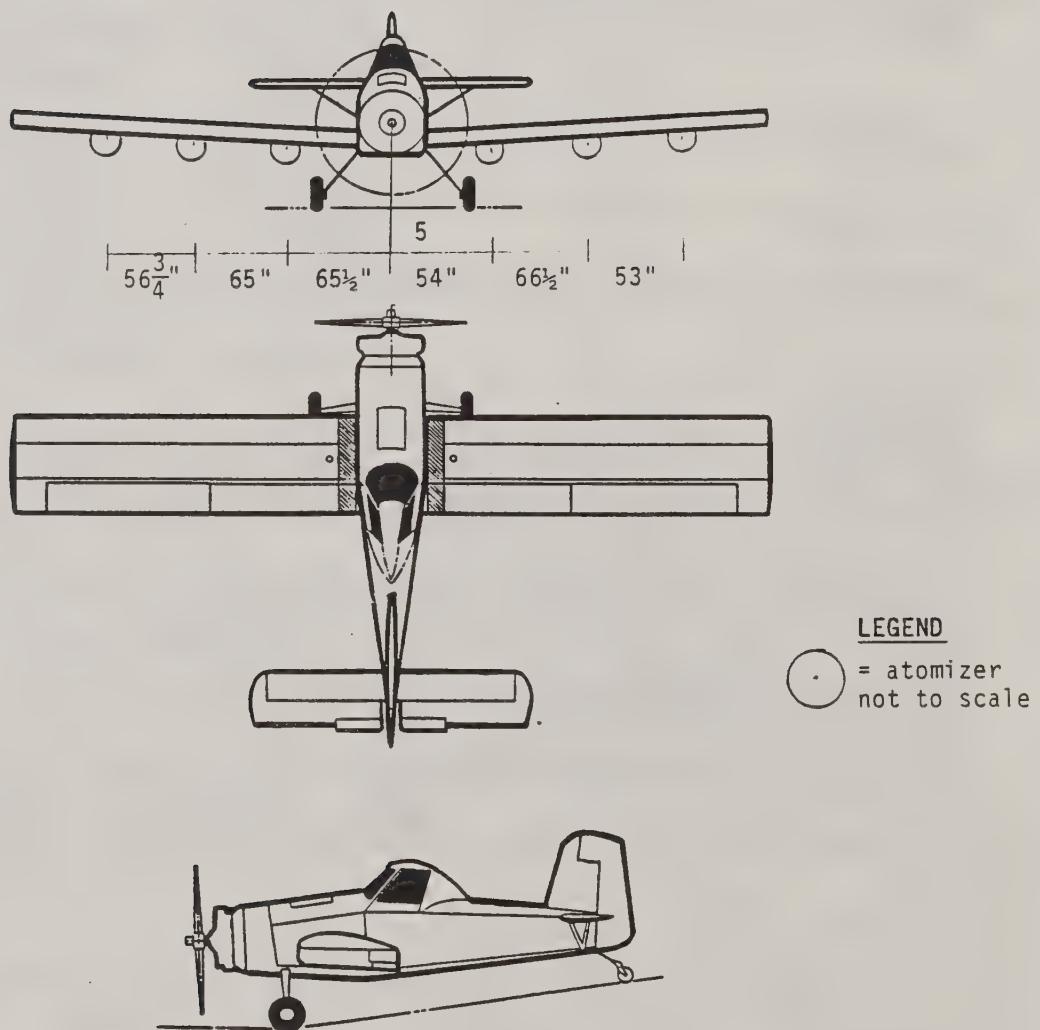
Wind speed, wind direction, wet and dry bulb temperature, and relative humidity were measured with instruments available in the FS fire belt weather kit. Recordings were made at the

Air Tractor, Incorporated

Air Tractor AT-301—Offers optional Transland dispersal equipment; also Aeroprop 4-blade pump fan, AU-3000 Micronair rotary atomizers. Same airframe as AT-400, except AT-301 has radial piston engine (Janes' 78-79, p. 251).

Type:	FW/SE/Ag/Mo/Lo
Engine:	Piston
Wingspan:	45.1 ft (13.75 m)
Max T-O wt:	7300 lb (3307 kg)
Useful load:	3400 lb (1540 kg)
In production:	Yes
No. produced:	550
Price FAF:	\$115,000 (U.S.)

See Appendix C, col. 6



1 in = 10 ft, 1 cm = 1.2 m Wingspan: 45.1 ft (13.75 m)

Air Tractor AT-301 (Air Tractor)

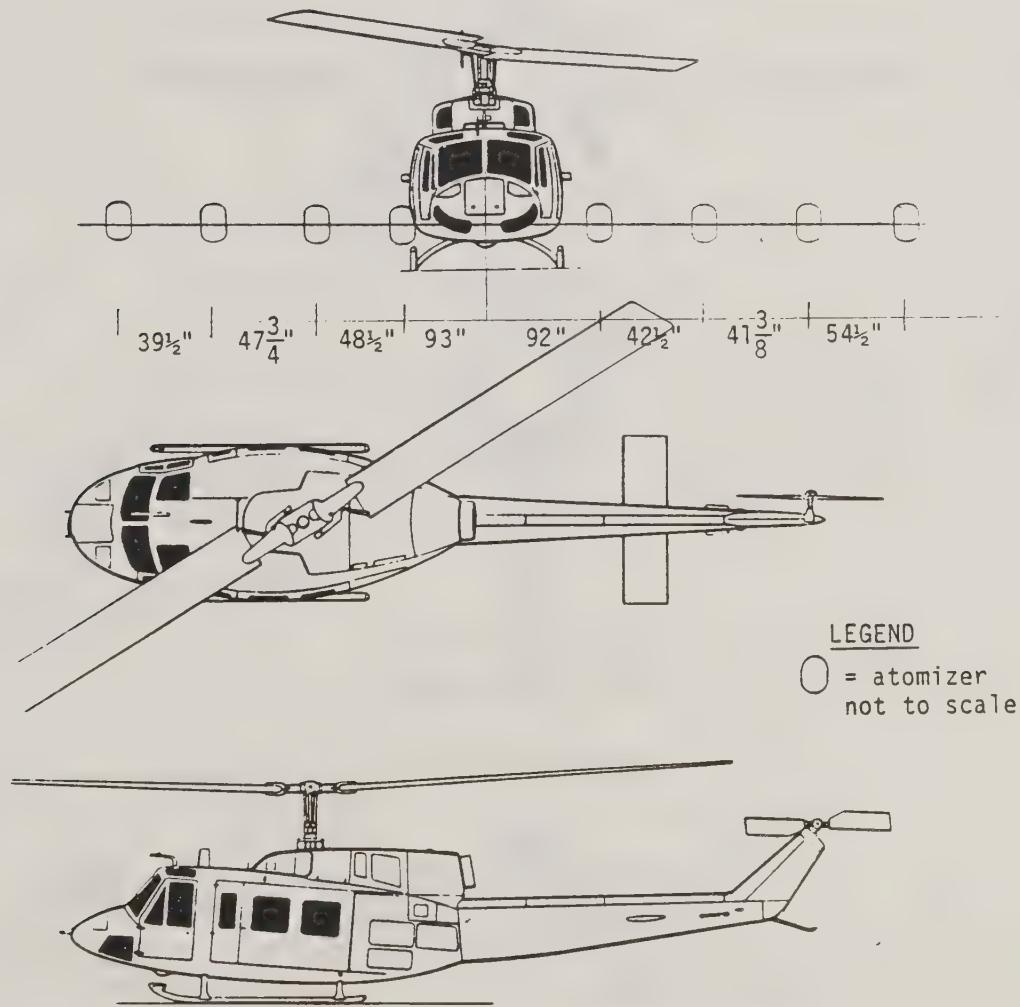
Figure 2. Position of Micronair atomizers on Air Tractor for trials 1-3, 5-7, and 11-14; Davis spray trials, March 1988. Base diagram from Hardy (1987).

Bell Helicopter Textron, Incorporated

Bell 205A-1—Model 205 is similar to 204 but has a larger fuselage and more cabin space. It is the commercial version of the military UH-1H Iroquois. The 205A-1 is designed for rapid conversion between freight, crane, ambulance, rescue, and personnel modes. Large doors on both sides will facilitate installing ag-dispersing equipment. It is produced under license to Augusta in Italy as AB205A-1 (Janes: 74-75, pp. 268-69).

Type:	RW/SE/Hvy/15
Engine:	Turboshaft
Rotor diam:	48 ft (14.63 m)
Max T-O wt:	10,500 lb (4763 kg)
Useful load:	5000 lb (2268 kg) (external)
In production:	
No. produced:	
Price FAF:	

See Appendix C, col. 101



1 in = 10 ft, 1 cm = 1.2 m Rotor Diam. 48 ft (14.63 m)

Bell 205 A-1; military UH-1H (Bell Helicopters Textron, Inc.)

Illustrated Encyclopedia, 1980

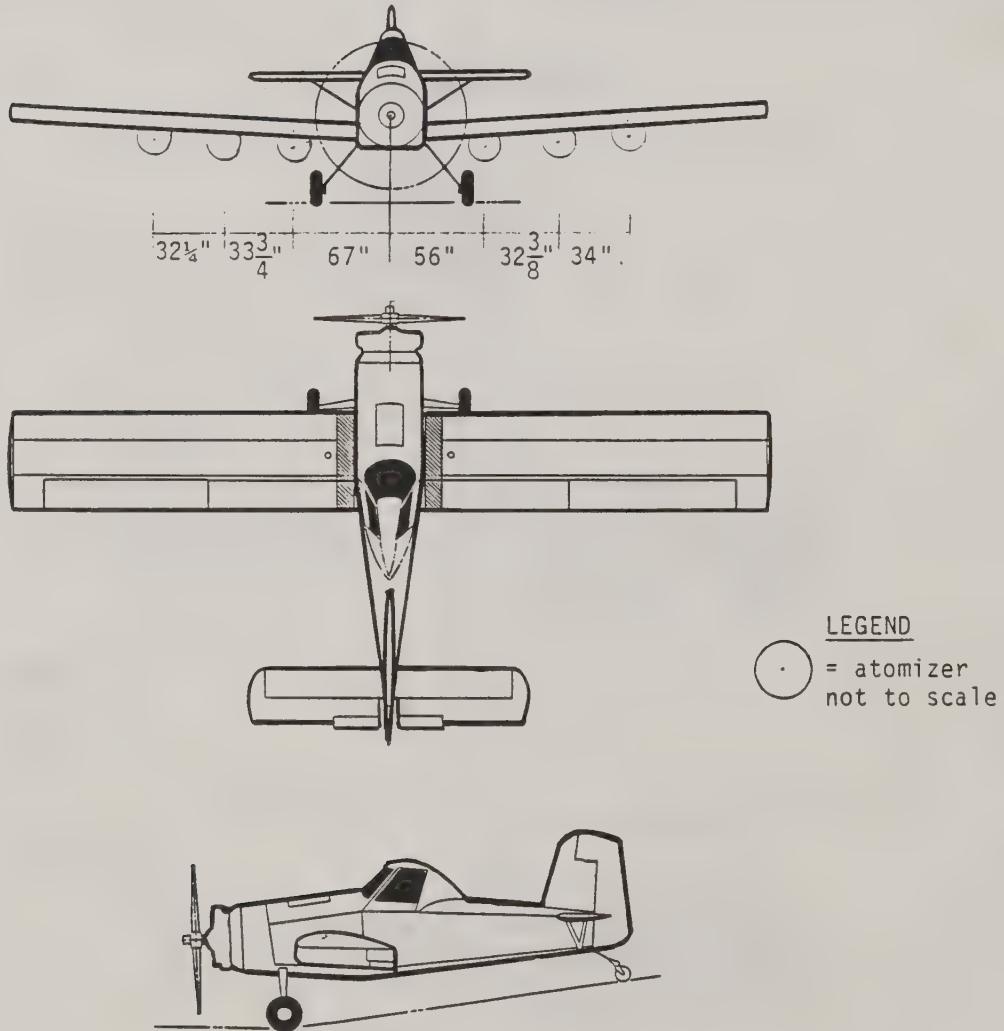
Figure 3. Position of Beecomist atomizers on Bell 205A-1 for trials 4, 8, 9, and 10; Davis spray trials, March 1988. Base diagram from Hardy (1987).

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Air Tractor AT-301—Offers optional Transland dispersal equipment; also Aeroprop 4-blade pump fan, AU-3000 Micronair rotary atomizers. Same airframe as AT-400, except AT-301 has radial piston engine (Janes' 78-79, p. 251).

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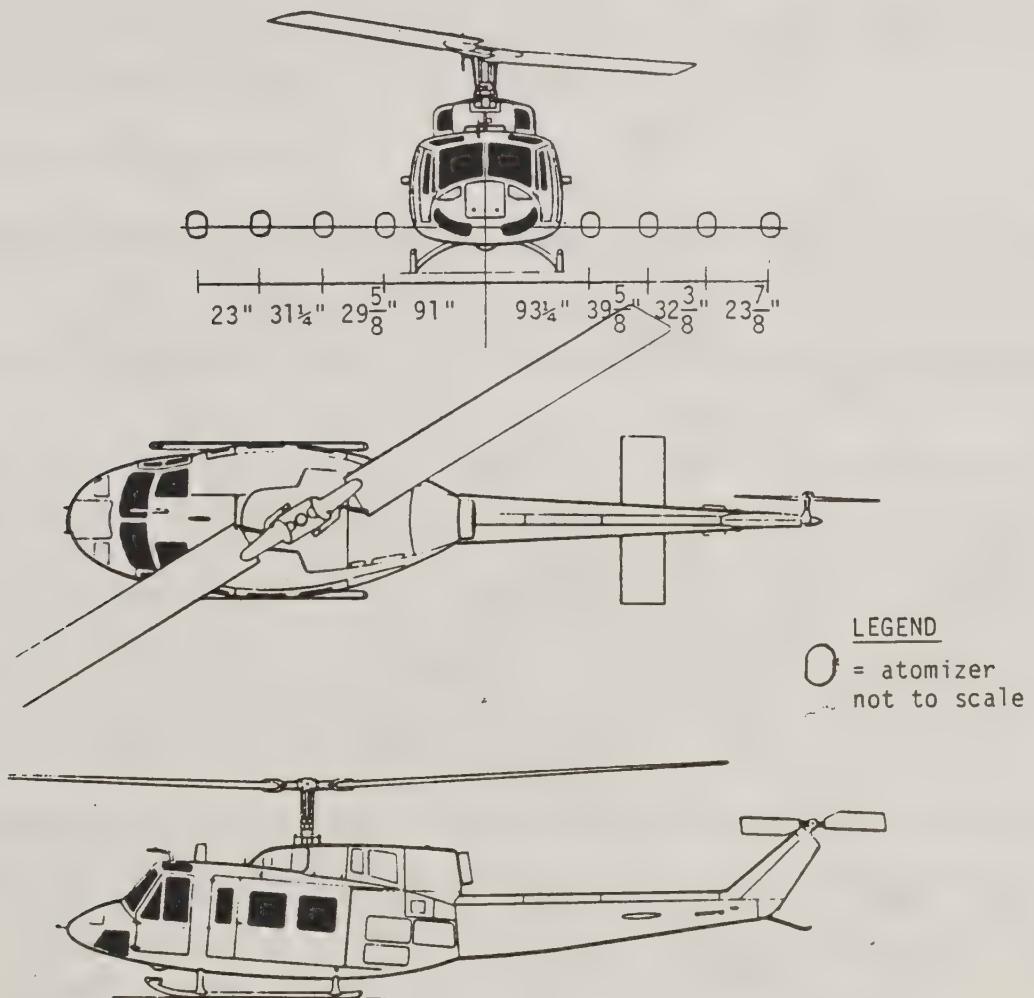
Figure 4. Position of Micronair atomizers on Air Tractor for trials 15, 16, 22-24, and 27-37; Davis spray trials, March 1988. Base diagram from Hardy (1987).

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Bell 205A-1—Model 205 is similar to 204 but has a larger fuselage and more cabin space. It is the commercial version of the military UH-1H Iroquois. The 205A-1 is designed for rapid conversion between freight, crane, ambulance, rescue, and personnel modes. Large doors on both sides will facilitate installing ag-dispersing equipment. It is produced under license to Augusta in Italy as AB205A-1 (Janes: 74-75, pp. 268-69).

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No. produced:	
Price FAF:	

See Appendix C, col. 101



1 in = 10 ft, 1 cm = 1.2 m *Rotor Diam. 48 ft (14.63 m)*

Bell 205 A-1; military UH-1H (Bell Helicopters Textron, Inc.)

Illustrated Encyclopedia, 1980

Figure 5. Position of Beecomist atomizers on Bell 205A-1 for trials 17-21, 25, 26, and 38-45; Davis spray trials, March 1988. Base diagram from Hardy (1987).

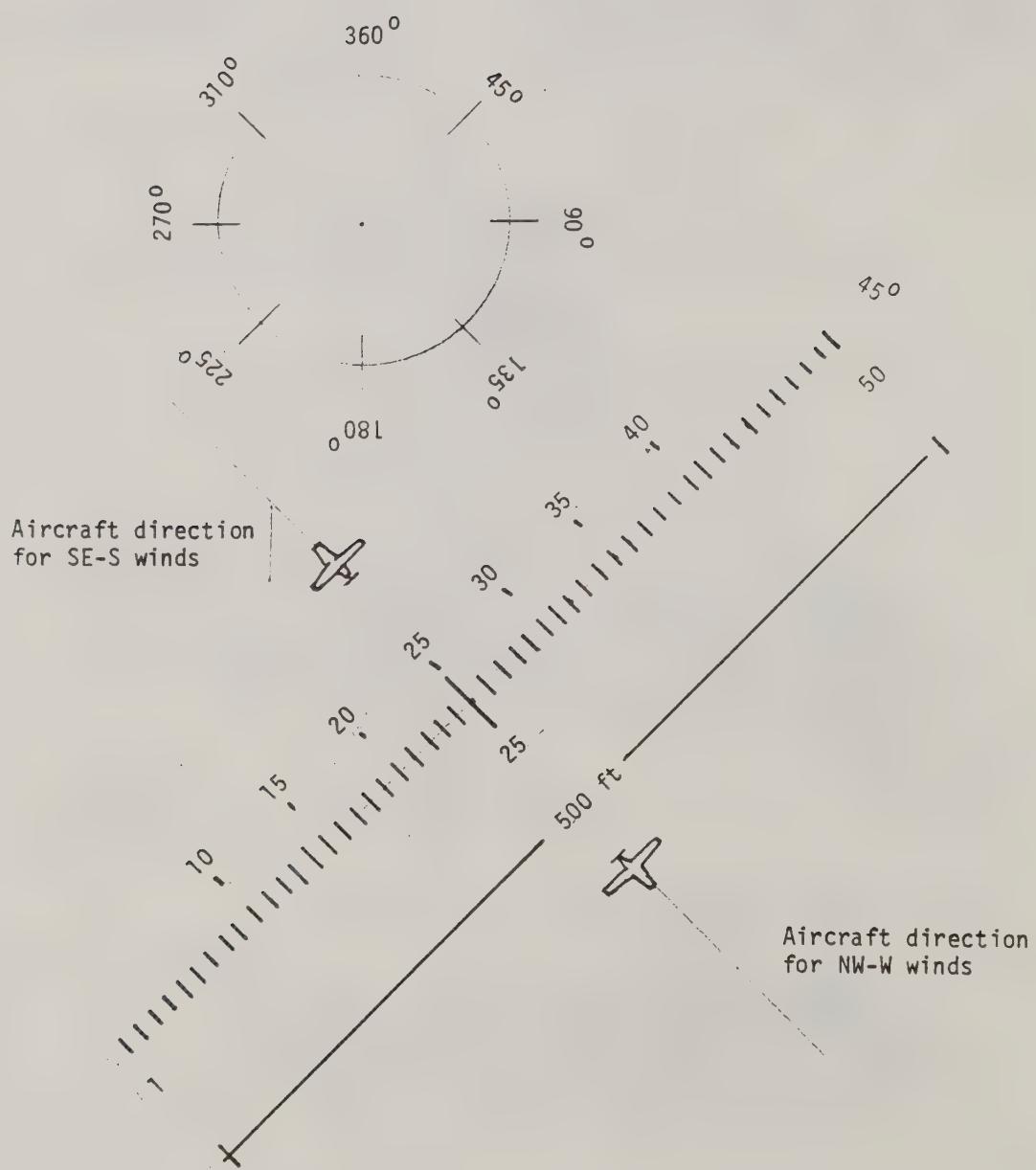


Figure 6. Layout of sample line and flight paths; Davis spray trials, March 1988. Card samplers every 10 feet (3.05 m), numbered 1 through 50. Foliage samples at positions 10, 15, 20, 25, 30, 35, and 40.

west end of the card line at 2 meters above the ground. Most of the surface winds were NW or SW and perpendicular to the card line. Under variable and very light winds (< 0.9 m/s; < 2 mph) the wind directions tended to be parallel to the card line. These conditions are noted in the trial summary data, Tables 2-10.

Spray deposit cards were assessed by four detailers from Eldorado NF and one from Nez Perce NF who used 7X powered hand-held oculars.

These trials were conducted over a range of weather conditions, by choice and not by design. Typically there was less than two hours of spray weather in the morning and less than one hour in the evening. Therefore, every opportunity was taken to conduct trials and to replicate conditions. Data over a range of conditions should, however, be helpful to the FS in planning and conducting aerial spray operations with these formulations.

RESULTS AND DISCUSSION

Data are provided on swath width and mean drop count within the swath width using a criteria of ≥ 10 drops per square centimeter. Volume median diameter (VMD) data are also presented as read from cards deposits. The swath width, mean drop deposit, and VMD data for ground cards are presented in Tables 2 - 10. All data in Tables 2 - 10 is from reading card deposits.

Deposition along the card line is presented in a series of bar graphs labeled Trials 1 through 45. There is no chart for trial 41 as it was considered a no data trial. Also, because of nature of the experiment and weather, there are no replicate trials, and the results presented herein will be based on single trials with similar characteristics. Drop counts below the threshold of 10 drops per square centimeters were not included in swath width, mean drop deposit, or VMD measurements. On trials where no swath width was measured due to deposition below the threshold, no further analysis was conducted. Therefore, for ground card deposition there is no swath width for trials 9, 13, 14, 17, 18, 19, 26, 33, and 36.

Table 2. Spray Characterization Trials for Dipel 6L Using the Aircraft Air Tractor 301 Equipped with the Micronair AU4000 Atomizer.

Trial #	Wind Speed (mph)	Wind Direction (°)	Temperature (°F)	Relative Humidity (%)	Swath Width (ft) >10 drops/cm ²	Mean Drops/cm ² Within Swath	Estimated VMD (μm)
1	10-12	300	44	78	130	17	68
2	15-18	320	46	76	60	19	114
3	18	320	52	67	150	44	151
5	7-10	320	62	20	250	32	-
6	8	280	55	34	150	11	121
7	5-6	310	56	46	150	13	151

Table 3. Spray Characterization Trials for Dipel 6L Using the Aircraft Bell 205 A1 Equipped with the Beecomist 360A Atomizer.

Trial #	Wind Speed (m/s)	Wind Direction (°)	Temperature (°F)	Relative Humidity (%)	Swath Width (m) >10 drops/cm ²	Mean Drops/cm ² Within Swath	Estimated VMD (μm)
38	1-2	120	70	37	330	12	159
39	< 1	120	68	42	150	17	148
40	< 1	120	65	48	210	15	102

Table 4. Spray Characterization Trials for Dipel 6L Using the Aircraft Bell 205 A1 Equipped with the Micronair AU5000 Atomizer.

Trial #	Wind Speed (mph)	Wind Direction (°)	Temperature (°F)	Relative Humidity (%)	Swath Width (ft) >10 drops/cm ²	Mean Drops/cm ² Within Swath	Estimated VMD (μm)
42	< 2	315	79	50	210	26	125
43	2-3	310	79	50	260	20	114
44	6	320	75	45	140	28	125
45	6	320	70	50	140	14	136

Table 5. Spray Characterization Trials for Dipel 6AF Using the Aircraft Bell 205 A1 Equipped with the Beecomist 360A Atomizer.

Trial #	Wind Speed (mph)	Wind Direction (°)	Temperature (°F)	Relative Humidity (%)	Swath Width (ft) >10 drops/cm ²	Mean Drops/cm ² Within Swath	Estimated VMD (μm)
4	12	320	65	27	40	13	91
8	1-2	320	40	44	40	12	57
9	3	280	37	90	0	-	-
10	2-3	310	42	53	60	14	91

Table 6. Spray Characterization Trials for Dipel 6AF Using the Aircraft Air Tractor 301 Equipped with the Micronair AU4000 atomizer.

Trial #	Wind Speed (mph)	Wind Direction (°)	Temperature (°F)	Relative Humidity (%)	Swath Width (ft) >10 drops/cm ²	Mean Drops/cm ² Within Swath	Estimated VMD (μm)
11	4-5	280	46	52	50	12	57
12	6-8	310	55	33	50	11	57
13	10	320	54	38	0	-	-
14	6-8	340	55	38	0	-	-
15	2-3	280	65	39	40	12	80
16	2-3	280	64	36	40	11	68
34	6	320	50	74	300	23	91
35	4	320	52	63	30	10	91
36	4-5	320	55	65	0	-	-
37	5	310	57	62	180	25	57

Table 7. Spray Characterization Trials for Thuricide 48LV Using the Aircraft Bell 205 A1 Equipped with the Beecomist 360A Atomizer.

Trial #	Wind Speed (mph)	Wind Direction (°)	Temperature (°F)	Relative Humidity (%)	Swath Width (ft) >10 drops/cm ²	Mean Drops/cm ² Within Swath	Estimated VMD (μm)
17	< 2	300	64	36	0	-	-
18	< 2	300	63	33	0	-	-
19	2-3	310	37	82	0	-	-
20	1-2	var	39	58	80	14	125
21	1-2	var	48	52	120	10	102

Table 8. Spray Characterization Trials for Thuricide 48LV Using the Aircraft Air Tractor 301 Equipped with the Micronair AU4000 Atomizer.

Trial #	Wind Speed (mph)	Wind Direction (°)	Temperature (°F)	Relative Humidity (%)	Swath Width (ft) >10 drops/cm ²	Mean Drops/cm ² Within Swath	Estimated VMD (μm)
22	1-2	0	42	68	270	28	102
23	2-3	225	47	66	190	15	91
24	3-4	65	49	61	30	11	114

Table 9. Spray Characterization Trials for Thuricide 32LV Using the Aircraft Bell 205 A1 Equipped with the Beecomist 360A Atomizer.

Trial #	Wind Speed (mph)	Wind Direction (°)	Temperature (°F)	Relative Humidity (%)	Swath Width (ft) >10 drops/cm ²	Mean Drops/cm ² Within Swath	Estimated VMD (μm)
25	4-5	50	53	74	240	16	148
26	3-4	135	55	72	0	-	-

Table 10. Spray Characterization Trials for Thuricide 32LV Using the Aircraft Air Tractor 301 Equipped with the Micronair AU4000 Atomizer.

Trial #	Wind Speed (mph)	Wind Direction (°)	Temperature (°F)	Relative Humidity (%)	Swath Width (ft) >10 drops/cm ²	Mean Drops/cm ² Within Swath	Estimated VMD (μm)
27	2-4	135	56	65	20	11	120
28	5	140	66	48	150	16	142
29	4	130	65	48	190	40	80
30	5	140	63	41	120	14	68
31	3-5	320	41	84	130	18	91
32	6	320	38	85	240	39	125
33	6	320	44	82	0	-	-

All trials where no swath width was observed were conducted with aqueous formulations. These tests were 29%, 38%, and 22% of Dipel 6AF, Thuricide 48LV, and Thuricide 32LV trials, respectively. Of 13 tests conducted with the oil-based formulation Dipel 6L, all had non-zero swath width.

For trials conducted under low wind speed and variable wind direction, the deposition patterns were inconsistent and showed no predictable pattern, being either uniformly or unevenly distributed over the ground-based card line. For trials where the wind direction coincided with aircraft track, the distribution over the ground-based line showed better uniformity, especially for trials with oil-based formulations. Droplets were deposited on the ground card line for all such trials. For the three other card positions (top and sides of stakes), there were trials with zero deposition (i.e., not even one droplet hit one card).

The mean droplet deposition in swath width ranged from 10 to 40 droplets per square centimeter with typical values about 15 droplets per square centimeter.

For cards positioned on top of the stakes, there is a zero swath width for trials 1, 4, 5, 8-20, and 23-40. Also, there were no droplets deposited for trial 45. The deposition pattern for stake top cards shows far more zero swath width trials when compared to ground cards. From

these trials, the position of the cards at the top of the stake is seen to be less reliable when compared to the ground cards.

Figure 7 shows the percentage of all trials for which a measurable swath width was obtained at each of the four sampling card positions. The position with the most frequent non-zero swath width was cards placed horizontally on the ground. The elevated sampling cards, 30 cm. above the ground surface, gave the smallest percentage of non-zero readings. The two positions on the side of the stakes, gave 59% and 20% non-zero readings for the north-west and south-east sides of the stake, respectively. However, these positions cannot be defined for field sampling until the direction of wind and the direction of flight is known, making their use much more cumbersome and subject to error when compared to the fixed procedure of placing sampling cards horizontally on the ground surface.

As the positions on the side of the stakes are difficult to define in advance of the actual test, and thus do not lend themselves to clear instructions in field test protocols, they were not included in further analysis. In addition to being difficult to state in advance, these positions did not offer an improvement of consistency in obtaining swath width measurements, with their best value at less than 75% of the frequency of success obtained from ground cards. If the procedure of placing cards on both sides of the stake was to be adopted in order to be sure and sample on the correct side of the stake, twice as many cards would be required in order to obtain results for less than 60% of the trials. If only one side were sampled, and that was defined in advance of the field work, results would likely be obtained in at best, 20% of the trials.

Figure 8 presents the swath width for the ground cards compared to the swath width for elevated (stake top) cards for all trials. Of the eight trials with non-zero elevated card readings, seven show a swath width less than that read from the ground cards. Similarly, Figure 9 indicates the coefficient of variation within the swath width, in percent, for each trial. In five of the eight trials, the coefficient of variation is lower when calculated from ground card deposits. Both of these measurements are important to the assessment of application performance in a non-biological fashion; ground cards tend to provide data under a wider variety of conditions, with larger values for swath width, and lower values for coefficient of variation.

Cards placed on the ground also gave a higher percentage of positive values for swath width under all wind directions. For trials where the wind direction was perpendicular to the card line and within plus or minus 45 degrees from perpendicular, the ground cards were successful at recording a swath width 76% of the time, while the elevated cards were successful only 67% of the trials. For those trials where the wind was within plus or minus 45 degrees of being parallel to the cardline, the comparable figures were 100 percent for the ground cards and 0% for the elevated cards. There were three trials where the wind was light and variable, with no established direction. For these trials the ground cards gave a 100% success rate again, while the elevated cards showed a 67% success rate.

Of 44 trials, ground cards on the ends of the sample line recorded deposits 34 times, or 77% of the trials. The majority of these occurrences were beyond the measured swath width, but the lack of clearly defined swath edges in some trials, and lack of complete information for calculating coefficient of variation in the other trials does cause uncertainty. Aircraft flights were

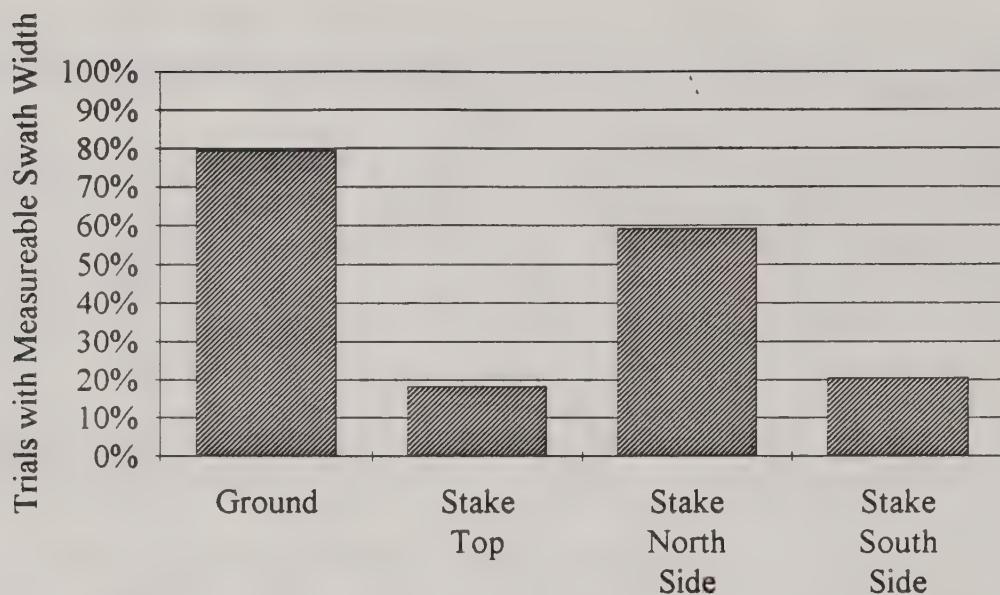


Figure 7. Percentage of trials for which measurable a swath width was obtained by position of the sampling card.

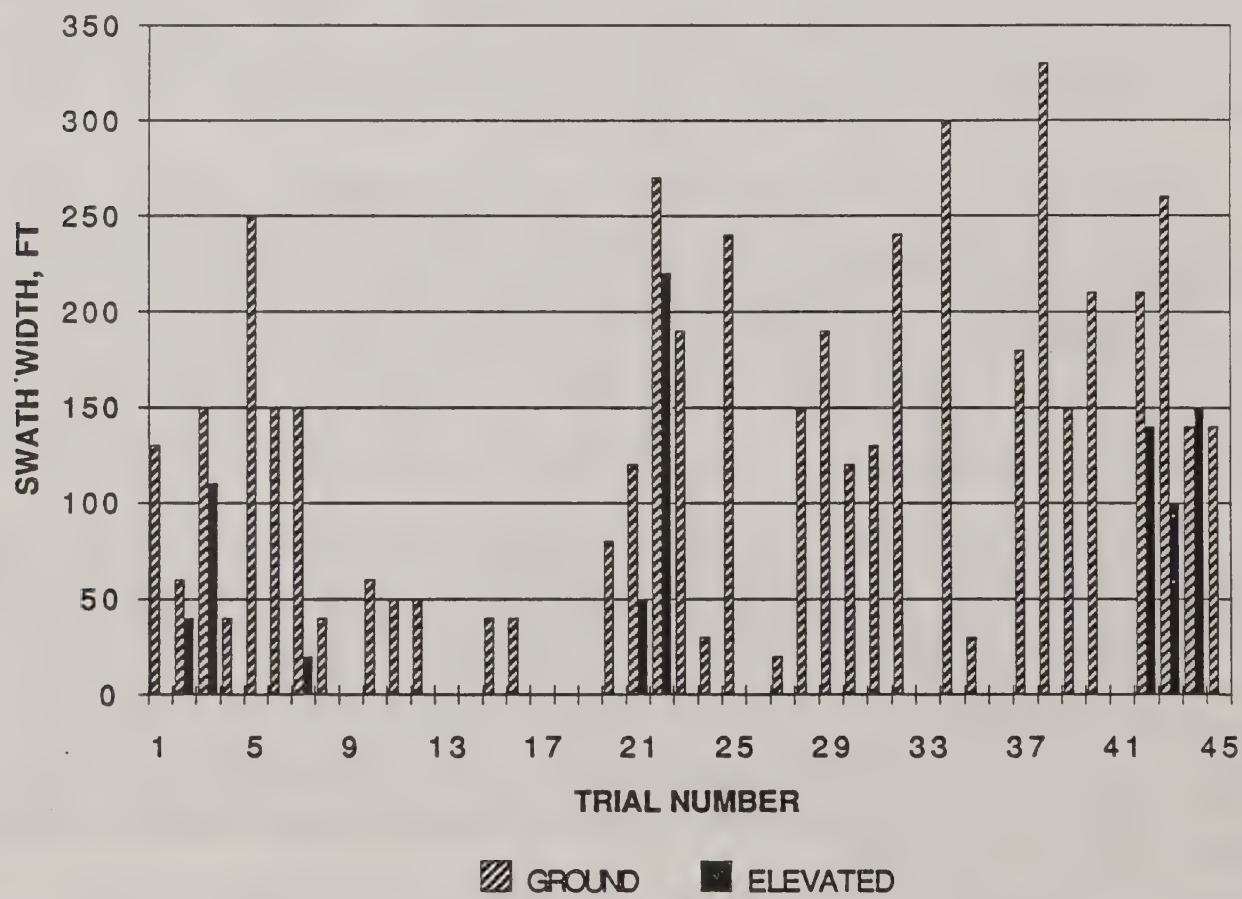


Figure 8. Swath width comparison for cards placed horizontally on the ground vs. cards placed horizontally 30 cm above the ground on top of stakes, by trial number.

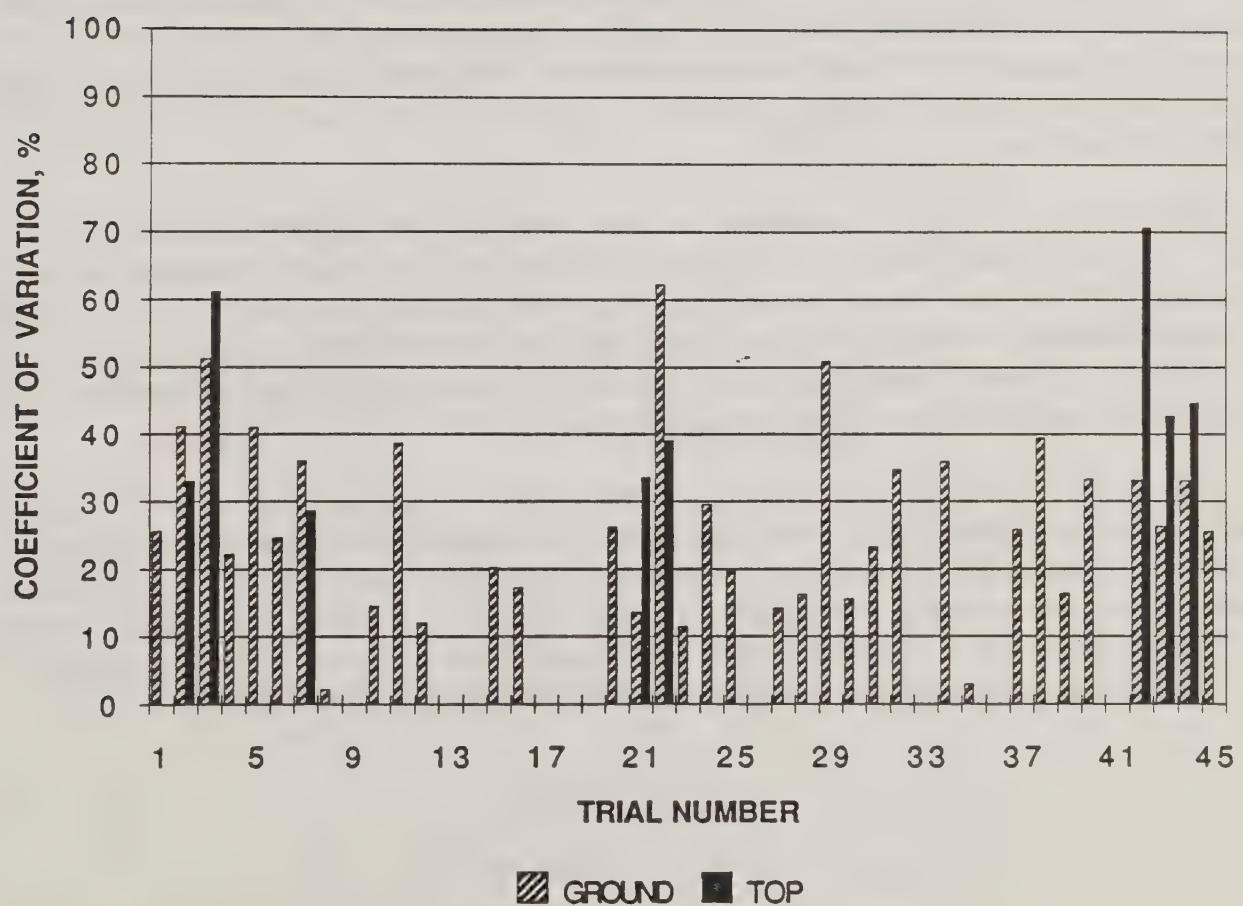


Figure 9. Coefficient of variation comparison for cards placed horizontally on the ground vs. cards placed horizontally 30 cm above ground on top of stakes, by trial number.

not centered on the cardline for these trials, but were moved upwind in an attempt to allow for wind displacement or offset of the swath deposit. In most cases, the offset chosen was not sufficient.

Figure 10 presents data points and a linear regression curve for swath width vs. total wind speed for ground cards during all trials conducted. As can be seen, there is no effect of wind speed on the swath width. Mean droplets per cm^2 vs. wind speed is shown in Figure 11. Again, there is no effect of wind upon this measured variable.

The coefficient of variation is plotted against mean deposition (drops/ cm^2) in Figure 12. As the mean number of droplets measured within the swath width increases, the coefficient of variation also increases. The most uniform pattern, in terms of droplets/ cm^2 , occurred just above the threshold of 10 droplets/ cm^2 chosen for inclusion in the swath width. Figure 13 presents the same data for stake top cards. This data series is sparse and shows no virtually correlation.

All trials where a swath width could not be determined when using ground cards were conducted with water based formulations. Similarly, of the five trials that showed a swath width greater than 76 meters (250 ft), only two were conducted with water based formulation. Of those two, one reported light and variable winds and the other showed winds only 5 degrees from parallel to the card line.

Tables 11,12,13, and 14 summarize the trials when grouped by formulation and type of aircraft. As can be seen, there is no obvious correlation between relative humidity and mean deposition within the swath for any set of trials. Water-based formulations show zero deposition with relative humidity as high as 90% and measurable deposits with relative humidity as low as 27%. Similarly, oil-based formulations show both high and low droplet densities over the entire range of relative humidity observed during these trials.

Table 15 summarizes the trials by release height, crosswind, and offset of deposit compared to center of flight path. Once again there is no apparent correlation that could lead to more effective placement of ground cards. Zero crosswind speeds resulted in offsets of from 0 to 13 cards. Crosswind speeds of more than zero resulted in offsets of from 0 to 27 cards, with the zero offset occurring with a 1 mph crosswind and 27 card offset occurring with a crosswind of 2 mph. This data also shows no fixed relationship between release height and offset.

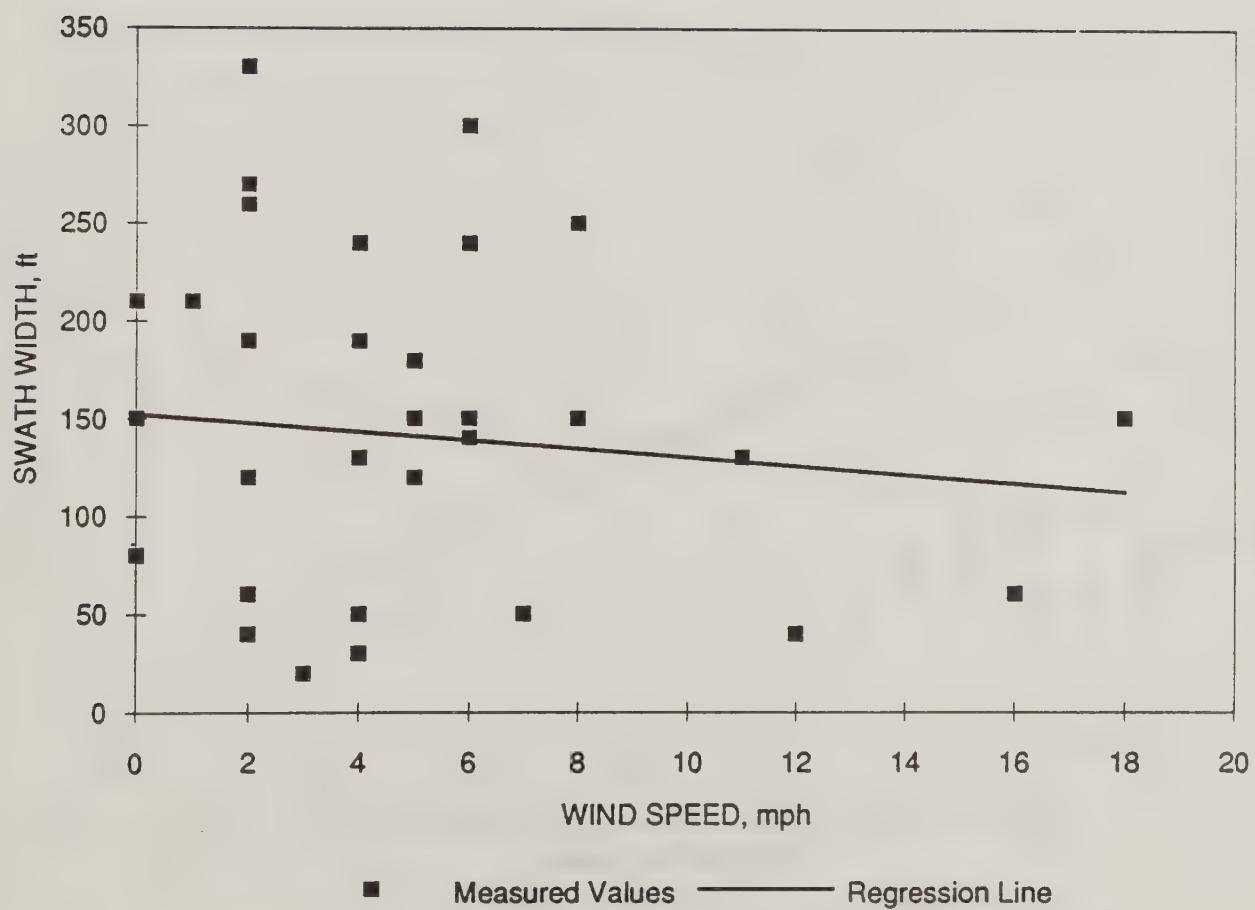


Figure 10. Swath width vs. wind speed for ground deposition cards, with regression line of swath width as a function of wind speed ($r^2 = 0.01$).

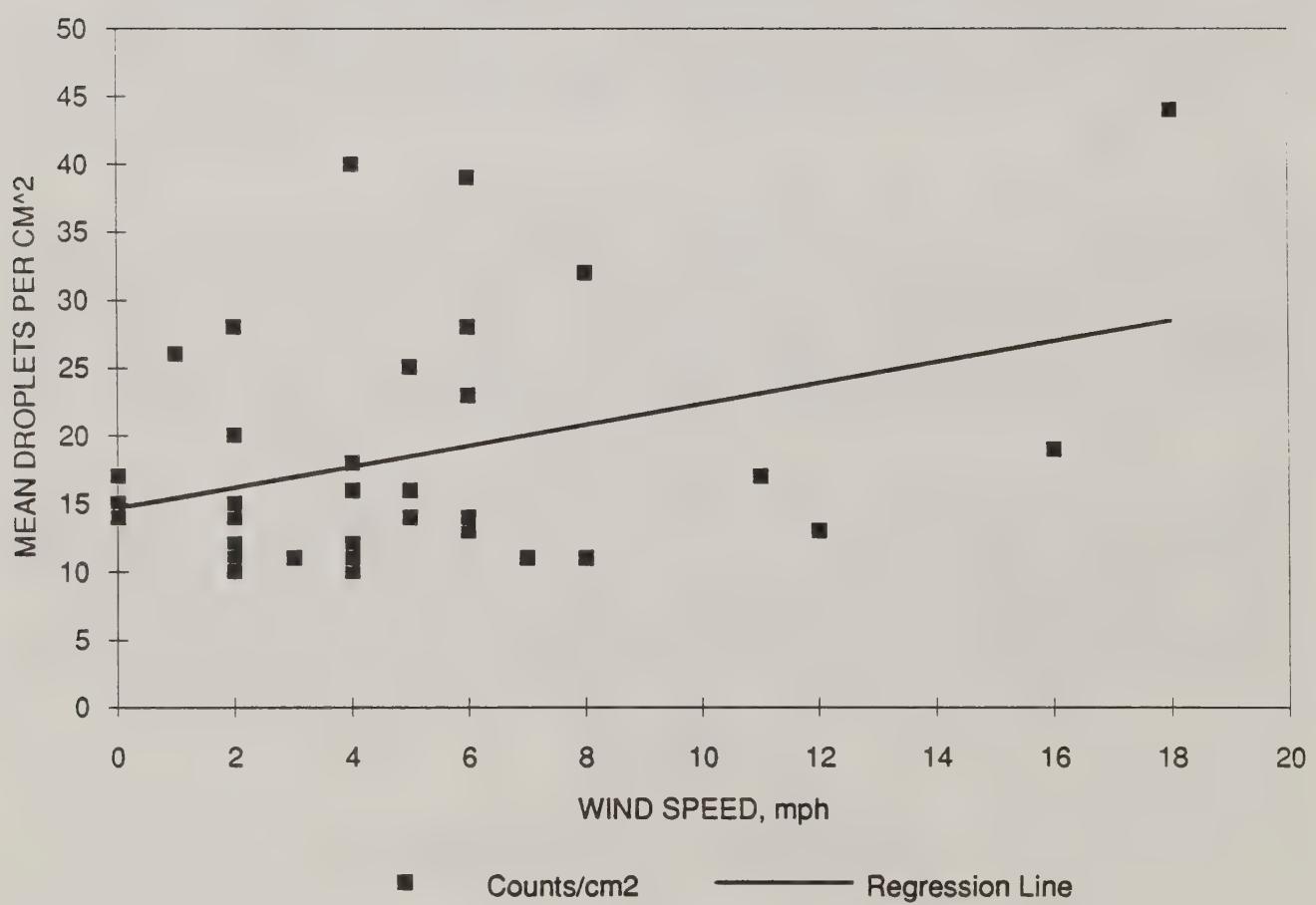
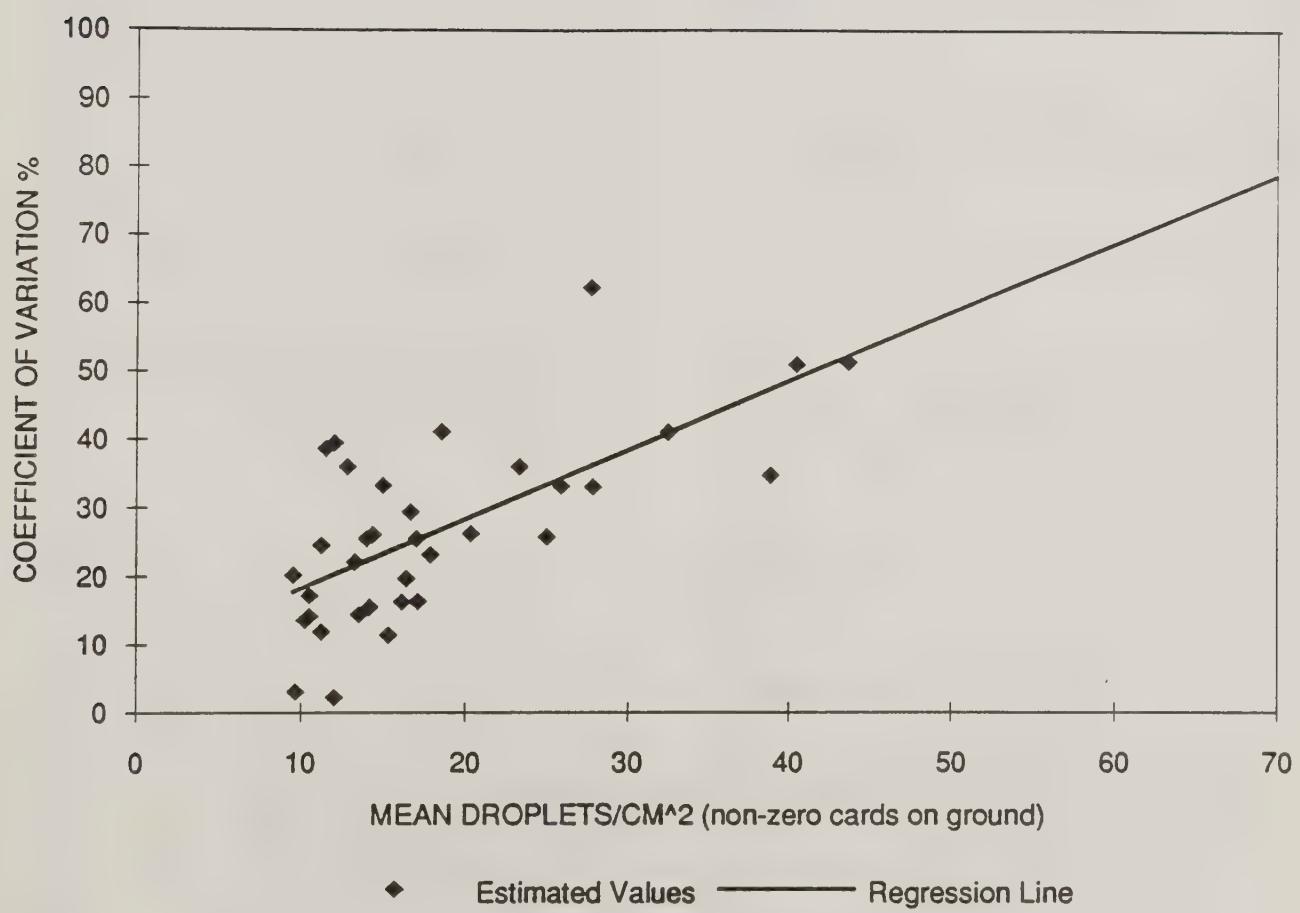


Figure 11. Mean droplets/ cm^2 deposited on ground cards as a function of wind speed for non-zero-swath trials ($r^2 = 0.12$).



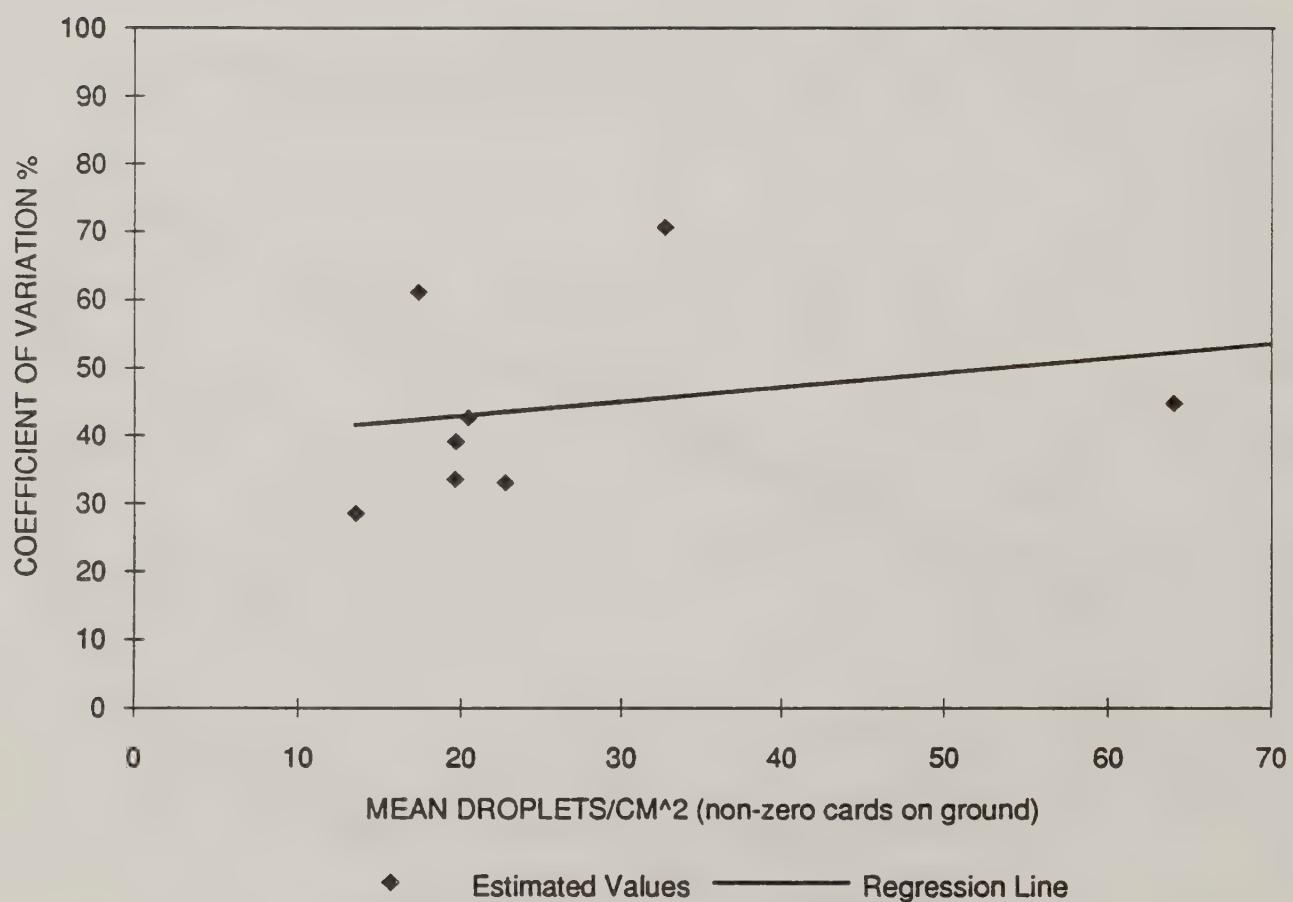


Figure 13. Coefficient of variation vs. mean deposition on stake top cards, including regression of coefficient of variation as function of mean droplets/cm² ($r^2 = 0.05$).

Table 11. Oil formulations sprayed with fixed-wing aircraft AT-301.

Trial #	Chemical	Aircraft	Atomizer	Wind Speed	Wind Direction	Headwind	Crosswind	Temp	Relative Humidity	Aircraft Height	Mean Droplets	Swath Width	Coef. of Variation
				m/s (mph)	degrees	m/s (mph)	°C (°F)	%	m (ft)	#/cm ²	m (ft)	%	
1	Dipel 6L	AT-301	Microair AU4000	4.9 (11)	300 (10.6)	4.7 (2.8)	6.7 (44)	78	15.2 (50)	17	39.6 (130)	25.6	
2	Dipel 6L	AT-301	Microair AU4000	7.2 (16)	320 (15.9)	7.1 (1.4)	7.8 (46)	76	12.2 (40)	19	18.3 (60)	41.1	
3	Dipel 6L	AT-301	Microair AU4000	8.0 (18)	320 (17.9)	8.0 (1.6)	0.7 (52)	67	12.2 (40)	44	45.7 (150)	51.2	
5	Dipel 6L	AT-301	Microair AU4000	3.6 (8)	320 (8.0)	3.6 (0.7)	0.3 (62)	20	15.2 (50)	32	76.2 (250)	41.1	
6	Dipel 6L	AT-301	Microair AU4000	3.6 (8)	280 (6.6)	2.9 (4.6)	2.1 (55)	34	15.2 (50)	11	45.7 (150)	24.5	
7	Dipel 6L	AT-301	Microair AU4000	2.7 (6)	310 (6.0)	2.7 (0.5)	0.2 (56)	46	16.7 (55)	13	45.7 (150)	36.0	

Table 12. Water formulations sprayed with fixed-wing aircraft AT-301.

Trial #	Chemical	Aircraft	Atomizer	Wind Speed	Wind Direction	Headwind	Crosswind	Temp	Relative Humidity	Aircraft Height	Mean Droplets	Swath Width	Coef. of Variation
				m/s (mph)	degrees	m/s (mph)	°C (°F)	%	m (ft)	#/cm ²	m (ft)	%	
11	Dipel 6AF	AT-301	Microair AU4000	1.8 (4)	280 (3.3)	1.5 (2.3)	1.0 (46)	7.8	52 (50)	15.2 (50)	12	15.2 (50)	38.6
12	Dipel 6AF	AT-301	Microair AU4000	3.1 (7)	310 (7.0)	3.1 (0.6)	0.3 (55)	12.8	33 (40)	12.2 (40)	11	15.2 (50)	12.0
13	Dipel 6AF	AT-301	Microair AU4000	4.5 (10)	320 (10.0)	4.5 (0.9)	0.4 (54)	12.2	38 (100)	30.5 (100)	-	-	-
14	Dipel 6AF	AT-301	Microair AU4000	3.1 (7)	340 (6.3)	2.8 (3.0)	1.3 (55)	12.8	38 (100)	30.5 (100)	-	-	-
15	Dipel 6AF	AT-301	Microair AU4000	0.9 (2)	280 (1.6)	0.7 (1.1)	0.5 (65)	18.3	39 (50)	15.2 (50)	10 (40)	12.2 (40)	20.2
16	Dipel 6AF	AT-301	Microair AU4000	0.9 (2)	280 (1.6)	0.7 (1.1)	0.5 (64)	17.8	36 (50)	15.2 (50)	11 (40)	12.2 (40)	17.2

Table 12 continued.

Trial #	Chemical	Aircraft	Atomizer	Wind Speed	Wind Direction	Headwind	Crosswind	Temp.	Relative Humidity	Aircraft Height	Mean Droplets #/cm ²	Swath Width m (ft)	Coef. of Variation %
34	Dipel 6AF	AT-301	Micronair AU4000	2.7 (6)	320	2.7 (6.0)	0.2 (0.6)	10.0 (50)	74	15.2 (50)	23	91.4 (300)	35.9
35	Dipel 6AF	AT-301	Micronair AU4000	1.8 (4)	320	1.8 (4.0)	0.2 (0.3)	11.1 (52)	63	30.5 (100)	10	9.1 (30)	2.9
36	Dipel 6AF	AT-301	Micronair AU4000	1.8 (4)	320	1.8 (4.0)	0.2 (0.3)	12.8 (55)	65	22.9 (75)	-	-	-
37	Dipel 6AF	AT-301	Micronair AU4000	2.2 (5)	310	2.2 (5.0)	0.2 (0.4)	13.9 (57)	62	15.2 (50)	25	54.9 (180)	25.8
27	Thuricide 32LV	AT-301	Micronair AU4000	1.3 (3)	135	1.3 (3.0)	0.0 (0.0)	13.3 (56)	65	15.2 (50)	11	6.1 (20)	14.1
28	Thuricide 32LV	AT-301	Micronair AU4000	2.2 (5)	140	2.2 (5.0)	0.2 (0.4)	18.9 (66)	48	13.7 (45)	16	45.7 (150)	16.3
29	Thuricide 32LV	AT-301	Micronair AU4000	1.8 (4)	130	1.8 (4.0)	0.2 (0.3)	18.3 (65)	48	15.2 (50)	40	57.9 (190)	50.9
30	Thuricide 32LV	AT-301	Micronair AU4000	2.2 (5)	140	2.2 (5.0)	0.2 (0.4)	17.2 (63)	51	15.2 (50)	14	36.6 (120)	15.6
31	Thuricide 32LV	AT-301	Micronair AU4000	1.8 (4)	320	1.8 (4.0)	0.2 (0.3)	5.0 (41)	84	15.2 (50)	18	39.6 (130)	23.2
32	Thuricide 32LV	AT-301	Micronair AU4000	2.7 (6)	330	2.6 (5.8)	0.7 (1.6)	3.3 (38)	85	15.2 (50)	39	73.2 (240)	34.8
33	Thuricide 32LV	AT-301	Micronair AU4000	2.7 (6)	320	2.7 (5.9)	0.2 (0.5)	6.7 (44)	82	15.2 (50)	-	-	-
22	Thuricide 48LV	AT-301	Micronair AU4000	0.9 (2)	0	0.6 (1.4)	0.6 (1.4)	5.6 (42)	68	15.2 (50)	28	82.3 (270)	62.2
23	Thuricide 48LV	AT-301	Micronair AU4000	0.9 (2)	225	0.0 (0.0)	0.9 (2.0)	8.3 (47)	66	15.2 (50)	15	57.9 (190)	11.4
24	Thuricide 48LV	AT-301	Micronair AU4000	1.8 (4)	65	0.6 (1.4)	1.7 (3.8)	9.4 (49)	61	15.2 (50)	17	9.1 (30)	29.5

Table 13. Oil formulations sprayed with rotary-wing aircraft Bell 205.

Trial #	Chemical	Aircraft	Atomizer	Wind Speed m/s (mph)	Wind Direction degrees	Headwind m/s (mph)	Crosswind m/s (mph)	Temp. °C (°F)	Relative Humidity %	Aircraft Height m (ft)	Mean Droplets #/cm ²	Swath Width m (ft)	Coef. of Variation %
38	Dipel 6L	Bell 205 A1	Beeconomist 360A	0.9 (2)	120 (1.9)	0.9 (0.5)	0.2 (0.5)	21.1 (70)	37 (50)	15.2 (50)	12 (50)	100.6 (330)	39.5
39	Dipel 6L	Bell 205 A1	Beeconomist 360A	0.0 (0)	120	-	-	20.0 (68)	42 (68)	15.2 (50)	17 (50)	45.7 (150)	16.4
40	Dipel 6L	Bell 205 A1	Beeconomist 360A	0.0 (0)	120	-	-	18.3 (65)	48 (65)	15.2 (50)	15 (50)	64.0 (210)	33.2
42	Dipel 6L	Bell 205 A1	Micronair AU5000	0.4 (1)	315 (1.0)	0.4 (0.0)	0.0 (0.0)	8.3 (47)	79 (47)	15.2 (50)	26 (50)	64.0 (210)	33.1
43	Dipel 6L	Bell 205 A1	Micronair AU5000	0.9 (2)	310 (2.0)	0.9 (0.2)	0.1 (0.2)	8.3 (47)	79 (47)	15.2 (50)	20 (50)	79.2 (260)	26.3
44	Dipel 6L	Bell 205 A1	Micronair AU5000	2.7 (6)	320 (6.0)	2.7 (0.5)	0.2 (0.5)	11.7 (53)	75 (53)	13.7 (45)	28 (45)	42.7 (140)	33.0
45	Dipel 6L	Bell 205 A1	Micronair AU5000	2.7 (6)	320 (6.0)	2.7 (0.5)	0.2 (0.5)	12.8 (55)	70 (55)	15.2 (50)	14 (50)	42.7 (140)	25.5

Table 14. Water formulations sprayed with rotary-wing aircraft Bell 205.

Trial #	Chemical	Aircraft	Atomizer	Wind Speed	Wind Direction	Headwind	Crosswind	Temp	Relative Humidity	Aircraft Height	Mean Droplets $\#/\text{cm}^2$	Swath Width m (ft)	Coef. of Variation %
				m/s (mph)	degrees	m/s (mph)	m/s (mph)	$^{\circ}\text{C}$ ($^{\circ}\text{F}$)	%	m (ft)			
4	Dipel 6AF	Bell 205 A1	Beecomist 360A	5.4 (12)	320	5.3 (12.0)	0.5 (1.0)	18.3 (65)	27	19.8 (65)	13	12.2 (40)	22.1
8	Dipel 6AF	Bell 205 A1	Beecomist 360A	0.9 (2)	320	0.9 (2.0)	0.1 (0.2)	4.4 (40)	44	19.8 (65)	12	12.2 (40)	2.2
9	Dipel 6AF	Bell 205 A1	Beecomist 360A	1.3 (3)	280	1.1 (2.5)	0.8 (1.7)	2.8 (37)	90	15.2 (50)	-	-	-
10	Dipel 6AF	Bell 205 A1	Beecomist 360A	0.9 (2)	310	0.9 (2.0)	0.1 (0.2)	5.6 (42)	53	15.2 (50)	14	18.3 (60)	14.5
25	Thuricide 32LV	Bell 205 A1	Beecomist 360A	1.8 (4)	50	0.2 (0.3)	1.8 (4.0)	11.7 (53)	74	15.2 (50)	16	73.2 (240)	19.7
26	Thuricide 32LV	Bell 205 A1	Beecomist 360A	1.8 (4)	135	1.8 (4.0)	0.0 (0.0)	12.8 (55)	72	15.2 (50)	-	-	-
17	Thuricide 48LV	Bell 205 A1	Beecomist 360A	0.4 (1)	300	0.4 (1.0)	0.1 (0.3)	17.8 (64)	36	13.7 (45)	-	-	-
18	Thuricide 48LV	Bell 205 A1	Beecomist 360A	0.4 (1)	300	0.4 (1.0)	0.1 (0.3)	17.2 (63)	33	15.2 (50)	-	-	-
19	Thuricide 48LV	Bell 205 A1	Beecomist 360A	0.9 (2)	308	0.9 (2.0)	0.1 (0.2)	2.8 (37)	82	15.2 (50)	-	-	-
20	Thuricide 48LV	Bell 205 A1	Beecomist 360A	0.0 (0)	0	-	-	3.9 (39)	58	15.2 (50)	14	24.4 (80)	26.2
21	Thuricide 48LV	Bell 205 A1	Beecomist 360A	0.9 (2)	0	0.6 (1.4)	0.6 (1.4)	8.9 (48)	52	15.2 (50)	10	36.6 (120)	13.6

Table 15. Offset of deposit compared to release height and crosswind.

Trial #	Observed Release Height m (ft)	Crosswind Absolute m/s (mph)	Cloud Cover	Deposit Center Card No.	Center of Pass Card No.	Offset m (ft)
1	15 (50)	1.3 (2.8)	clear	33	25	24.4 (80)
2	12 (40)	0.6 (1.4)	clear	19.5	20	1.5 (5)
3	12 (40)	0.7 (1.6)	clear	20	20	0.0 (0)
4	18 - 21 (60 - 70)	0.5 (1.0)	clear	36.5	25	35.1 (115)
5	15 (50)	0.3 (0.7)	clear	38	25	39.6 (130)
6	15 (50)	2.1 (4.6)	clear	34	16	54.9 (180)
7	17 (55)	0.2 (0.5)	clear	43	16	82.3 (270)
8	20 (65)	0.1 (0.2)	clear	31.5	25	19.8 (65)
9	15 (50)	0.8 (1.7)	clear	-	20	-
10	15 (50)	0.1 (0.2)	clear	27.5	15	38.1 (125)
11	15 (50)	1.0 (2.3)	clear	23	15	24.4 (80)
12	12 (40)	0.3 (0.6)	clear	14	14	0.0 (0)
13	30 (100)	0.4 (0.9)	clear	-	20	-
14	30 (100)	1.3 (3.0)	clear	-	20	-
15	15 (50)	0.5 (1.1)	clear	26.5	19	22.8 (75)
16	15 (50)	0.5 (1.1)	clear	26.5	19	22.8 (75)
17	14 (45)	0.1 (0.3)	clear	-	19	-
18	15 (50)	0.1 (0.3)	clear	-	19	-
19	15 (50)	0.1 (0.2)	clear	-	19	-
20	15 (50)	-	clear	5.5	19	41.1 (135)
21	15 (50)	0.6 (1.4)	clear	25.5	25	1.5 (5)
22	15 (50)	0.6 (1.4)	clear	37	20	51.8 (170)
23	not observed	0.9 (2.0)	clear	36	25	33.5 (110)
24	not observed	1.7 (3.8)	clear	16	25	27.4 (90)
25	15 (50)	1.8 (4.0)	clear	27.5	37	29.0 (95)
26	15 (50)	0.0 (0.0)	clear	-	37	-
27	15 (50)	0.0 (0.0)	clear	23.5	25	4.6 (15)
28	14 (45)	0.2 (0.4)	clear	20	25	15.2 (50)
29	15 (50)	0.2 (0.3)	clear	17	25	24.4 (80)
30	15 (50)	0.2 (0.4)	clear	18.5	25	19.8 (65)
31	15 (50)	0.2 (0.3)	clear	20	25	15.2 (50)
32	15 (50)	0.7 (1.6)	clear	12.5	25	38.1 (125)
33	15 (50)	0.2 (0.5)	clear	-	27	-
34	15 (50)	0.2 (0.6)	clear	16.5	32	47.2 (155)
35	30 (100)	0.2 (0.3)	clear	19	32	39.6 (130)
36	23 (75)	0.2 (0.3)	clear	-	40	-
37	15 (50)	0.2 (0.4)	clear	31.5	40	25.9 (85.5)
38	15 (50)	0.2 (0.5)	clear	23	35	36.6 (120)
39	15 (50)	-	clear	27	35	24.4 (80)
40	15 (50)	-	clear	40	35	15.2 (50)
41	no data trial					
42	15 (50)	0.0 (0.0)	clear	34	34	0.0 (0)
43	15 (50)	0.1 (0.2)	clear	28.5	34	16.8 (55)
44	14 (45)	0.2 (0.5)	clear	23.5	19	13.7 (45)
45	15 (50)	0.2 (0.5)	clear	17.5	19	4.6 (15)

CONCLUSIONS

1. Sampling cards should be placed on the ground surface for the highest probability of measuring a positive swath width.
2. Elevated cards tended to show zero swath widths more frequently, and also showed lower deposition in droplets/cm², and higher values for coefficient of variation within the swath width.
3. Cards placed on the sides of stakes also give less consistent results. In addition, the number of samplers must be doubled in order to cover all possibilities for wind direction and flight path. It is also difficult to clearly and unambiguously state sampler location in the experiment protocol, as the optimum location for a single vertical sampler depends on stake orientation, wind direction, and flight direction.
4. In order to capture all deposits, the perpendicular cardline should be extended laterally for field characterization. The exact length should be on the order of 200 meters (656 ft.). Card spacing could be increased to 4 meters on the sample line, and still not increase the number of cards or readings over the trials.
5. Swath width and mean deposition (drops/cm²) as measured with ground cards, are essentially independent of wind speed.
6. The most uniform pattern, in terms of droplets/cm², occurred just above the threshold of 10 droplets/cm² chosen for inclusion in the swath width.

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APPENDICES

Appendix A. Ground Card Data

Appendix B. Stake Top Data

Appendix C. Stake North Side Data

Appendix D. Stake South Side Data

APPENDIX A

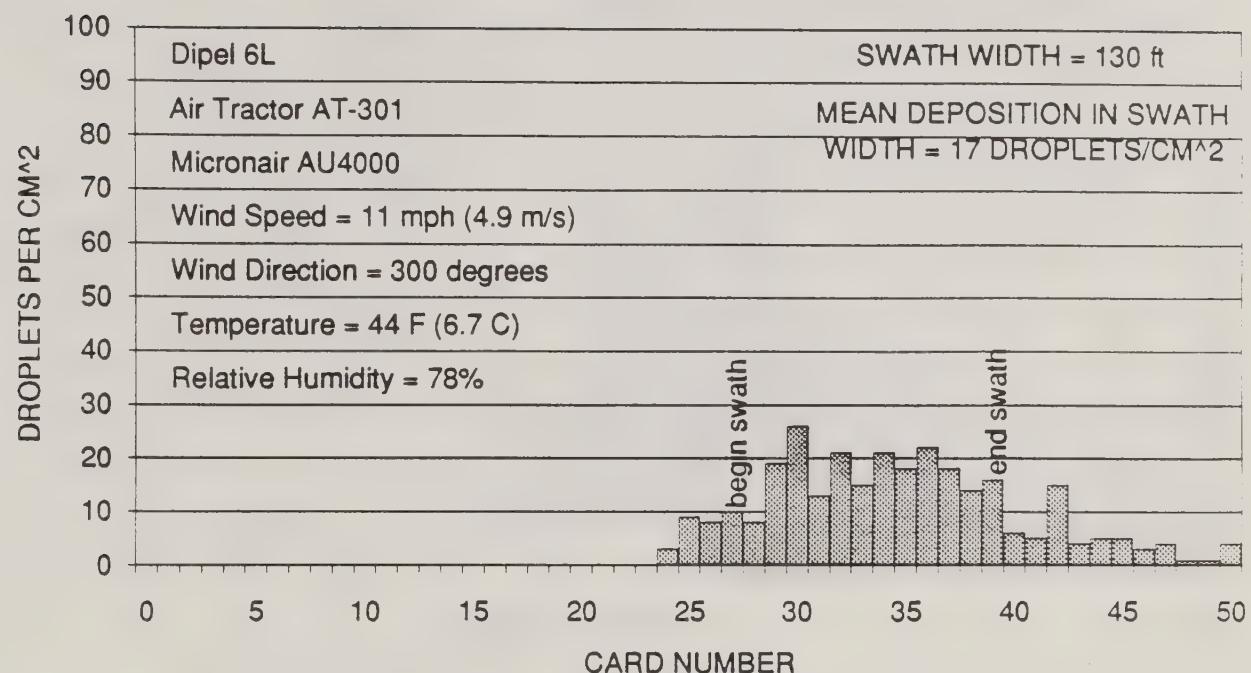
Trial Data and Ground Card Deposits in Tabular and Graphical Form

Appendix A - Trial Data and ground card deposits in tabular and graphical form

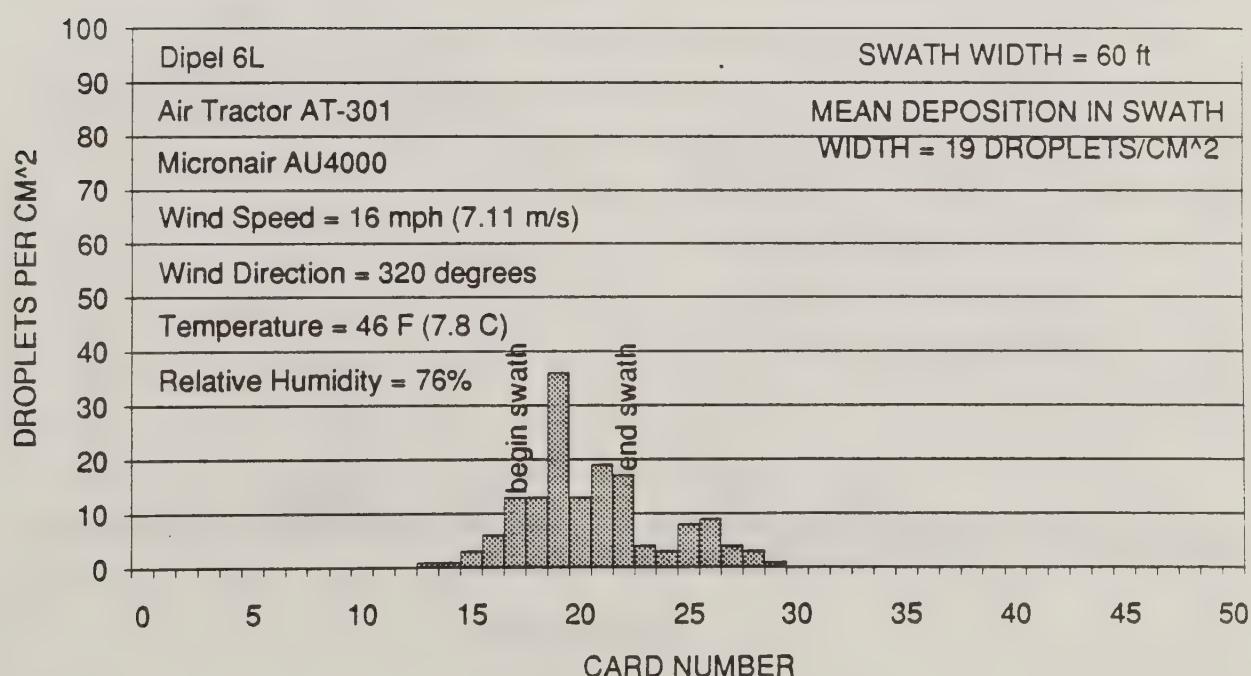
Trial #	Chemical	Aircraft	Nozzle	GC1	GC2	GC3	GC4	GC5	GC6	GC7	GC8	GC9	GC10	GC11	GC12	GC13	GC14	GC15	GC16	GC17	GC18	GC19	GC20	GC21	GC22	GC23	GC24	GC25	
1	DIPEL 6L	AT-301	AU4000	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
2	DIPEL 6L	AT-301	AU4000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	9	9	
3	DIPEL 6L	AT-301	AU4000	2	4	2	3	3	2	4	8	8	14	4	4	11	26	34	76	78	41	65	57	54	79	64	28	21	
4	DIPEL 6AF	B-205	BEECOMIST																										
5	DIPEL 6L	AT-301	AU4000																									2	
6	DIPEL 6L	AT-301	AU4000																										
7	DIPEL 6L	AT-301	AU4000																										
8	DIPEL 6AF	B-205	BEECOMIST																										
9	DIPEL 6AF	B-205	BEECOMIST																										
10	DIPEL 6AF	B-205	BEECOMIST																										
11	DIPEL 6AF	AT-301	AU4000																										
12	DIPEL 6AF	AT-301	AU4000	1	2	1	2	1	3	2	4	3	1	1	1	2	3	1	1	1	1	1	1	1	1	1	1		
13	DIPEL 6AF	AT-301	AU4000	3	2	1	2	1	1	0	2	3	3	4	4	3	2	5	6	7	3	4	4	4	2	1	1		
14	DIPEL 6AF	AT-301	AU4000																										
15	DIPEL 6AF	AT-301	AU4000																										
16	DIPEL 6AF	AT-301	AU4000																										
17	THUR 48LV	B-205	BEECOMIST																										
18	THUR 48LV	B-205	BEECOMIST																										
19	THUR 48LV	B-205	BEECOMIST	10	8	2	2	2	2	3	4	4	3	3	4	2	2	3	2	4	3	4	3	3	3	2	2		
20	THUR 48LV	B-205	BEECOMIST	5	20	17	12	9	16	12	9	12	6	5	8	5	4	3	2	2	1	2	0	1	1	4	5		
21	THUR 48LV	B-201	BEECOMIST																										
22	THUR 48LV	AT-301	AU4000	1																									
23	THUR 48LV	AT-301	AU4000																										
24	THUR 48LV	AT-301	AU4000	2	3	3	3	5	6	8	18	7	7	8	6	9	7	7	17	21	12	9	7	1	1	1	1		
25	THUR 32LV	B-205	BEECOMIST	7	4	3	4	5	3	3	4	3	2	3	6	8	18	14	18	17	11	19	24	16	17	17	17		
26	THUR 32LV	B-205	BEECOMIST	2	1	0	1	1	2	1	1	2	3	1	1	1	1	0	1	2	1	2	1	4	5	3	3		
27	THUR 32LV	AT-301	AU4000																										
28	THUR 32LV	AT-301	AU4000	1	2	1	1	5	4	11	7	9	12	18	14	14	20	18	13	21	20	19	15	18	14	14	14		
29	THUR 32LV	AT-301	AU4000	2	1	3	3	6	9	8	18	60	33	20	16	28	34	33	32	60	51	81	69	60	13	18	18	18	
30	THUR 32LV	AT-301	AU4000																										
31	THUR 32LV	AT-301	AU4000																										
32	THUR 32LV	AT-301	AU4000	14	19	27	33	25	26	31	42	34	38	60	56	52	61	57	50	31	40	47	64	42	31	20	9	9	
33	THUR 32LV	AT-301	AU4000	1	0	0	0	2	1	0	1	1	2	4	5	3	4	3	3	4	3	4	5	10	9	8	8	8	
34	DIPEL 6AF	AT-301	AU4000	8	11	13	15	15	18	17	18	22	21	18	16	33	27	30	30	33	19	18	18	19	28	25	29	25	25
35	DIPEL 6AF	AT-301	AU4000	1	2	1	2	1	3	4	6	8	8	7	5	5	7	7	6	10	8	11	3	4	3	4	4	4	
36	DIPEL 6AF	AT-301	AU4000	1	1	1	1	3	3	4	3	2	3	2	1	2	3	2	3	3	2	3	1	3	3	2	2	2	
37	DIPEL 6AF	AT-301	AU4000	1	1	1	0	0	0	2	1	5	4	3	5	3	3	3	3	3	4	2	5	27	21	19	19	19	
38	DIPEL 6L	B-205	BEECOMIST	6	7	10	7	8	8	12	9	11	14	9	8	12	9	13	17	10	12	11	9	6	11	10	12	12	
39	DIPEL 6L	B-205	BEECOMIST	3	4	8	10	11	6	9	8	7	5	7	4	5	7	7	10	9	9	12	13	21	21	18	18	18	
40	DIPEL 6L	B-205	BEECOMIST	1																									
41	NO	TRIAL	#41																										
42	DIPEL 6L	B-205	AU5000																										
43	DIPEL 6L	B-205	AU5000																										
44	DIPEL 6L	B-205	AU5000																										
45	DIPEL 6L	B-205	AU5000	1	2	3	2	6	5	5	7	8	13	26	11	7	12	19	13	14	15	18	10	9	11	9	11	9	

GC26	GC27	GC28	GC29	GC30	GC31	GC32	GC33	GC34	GC35	GC36	GC37	GC38	GC39	GC40	GC41	GC42	GC43	GC44	GC45	GC46	GC47	GC48	GC49	GC50	MEAN	STDEV	CV(%)
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	49	50	26
8	10	8	19	26	13	21	15	21	18	22	18	14	16	6	5	15	4	5	5	3	4	1	1	4	17	5.03	26
9	4	3	1																						19	8.94	41
11	10	4	6	1																					44	25.45	51
3	5	8	6	4	6	5	4	6	19	13	10	11	6	2	9	3	1	2	4	3	2	3	1	2	13	4.03	22
15	35	39	38	50	57	40	39	47	56	40	39	32	26	28	47	32	10	19	29	17	18	31	15	13	32	13.48	41
4	11	19	17	6	11	13	18	5	12	13	11	10	11	10	10	9	8	7	7	5	7	10	7	5	11	3.94	25
3	4	6	5	6	8	13	1	6	7	11	12	10	11	10	16	9	13	9	22	21	11	12	10	15	13	4.06	36
7	9	8	6	11	13	12	12	8	5	6	9	9	9	7	7	5	5	3	3	2	3	2	3	1	12	0.82	2
1	1	2	2	6	3	2	2	2	1	1	1	2	2	2	1	1	2	1	1	0	1	0	2	1	#N/A	#N/A	#N/A
15	22	10	4	11	6	7	8	9	7	6	3	1	8	7	8	7	7	3	3	5	3	5	4	14	6.53	15	
7	4	4	2	3	2	4	1	0	8	1	6	5	3	7	7	5	6	4	5	4	4	3	5	12	0.71	39	
7	10	9	7	9	6	6	5	4	3	3	3	2	2	1	1	1	2	2	2	1	1	1	11	3.77	12		
1																									#N/A	#N/A	#N/A
6	9	11	6	6	4	4	4	7	5	4	4	3	3	4	5	5	4	5	8	6	7	6	4	3	10	2.65	20
12	13	12	4	10	6	2	5	2	4	11	3	3	6	2	2	5	2	5	2	1	2	3	2	2	11	3.33	17
2	2	2	3	3	4	3	3	4	3	4	4	3	3	2	2	1	2	2	1	2	1	1	2	1	#N/A	#N/A	#N/A
2	3	2	1	1	2	1	1	2	1	1	0	1	1	0	1	1	0	1	0	2	1	2	1	2	#N/A	#N/A	#N/A
1	1	1																							#N/A	#N/A	#N/A
11	9	8	13	13	11	8	10	7	9	10	6	5	8	7	4	6	4	4	3	4	3	3	1	2	10	1.66	14
25	32	18	23	18	26	53	57	40	64	77	34	40	25	22	19	29	21	16	8	12	8	11	15	15	28	17.48	62
8	13	15	13	14	15	19	18	16	17	15	16	19	15	14	13	15	15	15	14	6	3	3	3	2	15	1.83	11
15	14	14	16	29	15	15	16	15	15	16	15	16	12	2	1										17	4.51	29
3	3	3	3	3	4	4	5	4	5	3	4	4	4	1											16	3.68	20
1																									11	0.71	14
16	10	8	2	1																				16	3.29	16	
13																									40	22.19	51
7	7	3	1																						14	3.07	16
13	4	4	3																						18	4.78	23
1																									39	14.31	35
1	2																								#N/A	#N/A	#N/A
55	31	25	22	34	14	5																		23	8.89	36	
3	4	4	4	3	2	1																		10	1.53	3	
3	3	2	2	4	2	2																		25	7.26	26	
11	13	12	24	25	27	28	36	32	26	31	28	31	26	33	7	4	1	2	1	1	1	1	1	12	5.26	39	
8	11	16	10	9	13	14	14	14	4	14	14	14	3	5	2	0	1	3	2	1	1	1	1	17	4.79	16	
21	25	22	19	20	12	19	10	11	4	3	1													17	4.51	29	
22	26	20	15	15	8	8	4	3	3	3	6	6	3	3	2	0	1	1	1	1	1	1	1	28	9.47	33	
9	8	13	12	15	12	15	12	15	12	18	21	16	17	8	10	7	4	0	1	1	1	1	1	14	4.93	25	

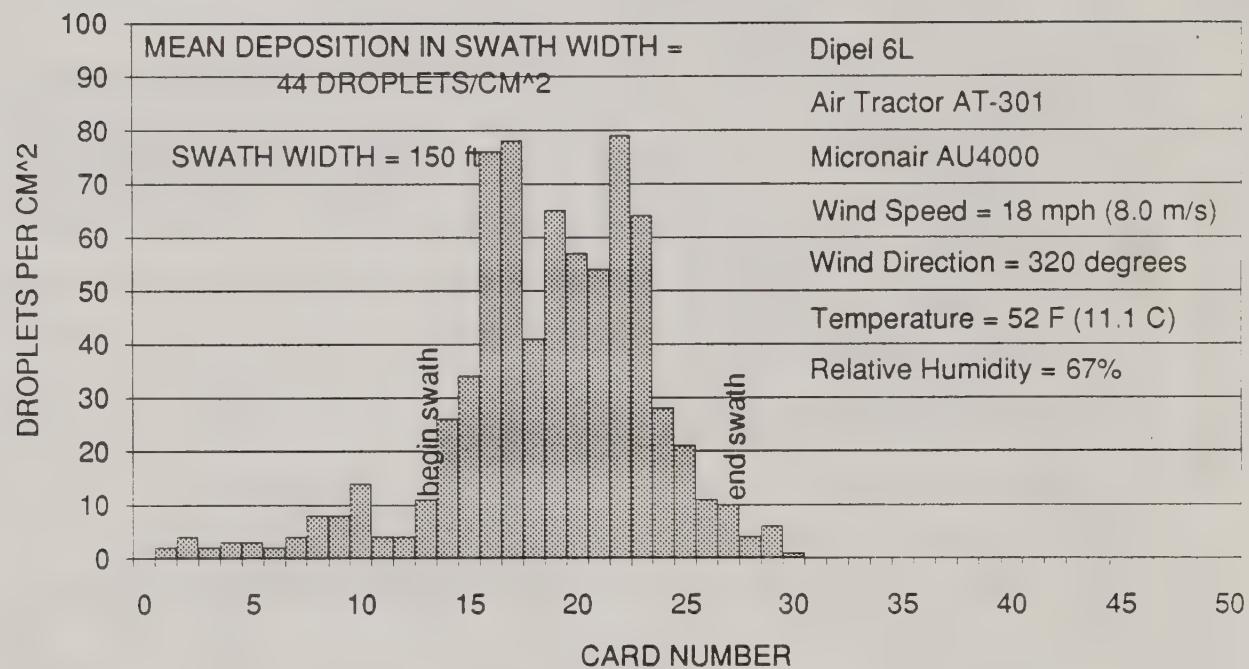
TRIAL 1 - GROUND CARD



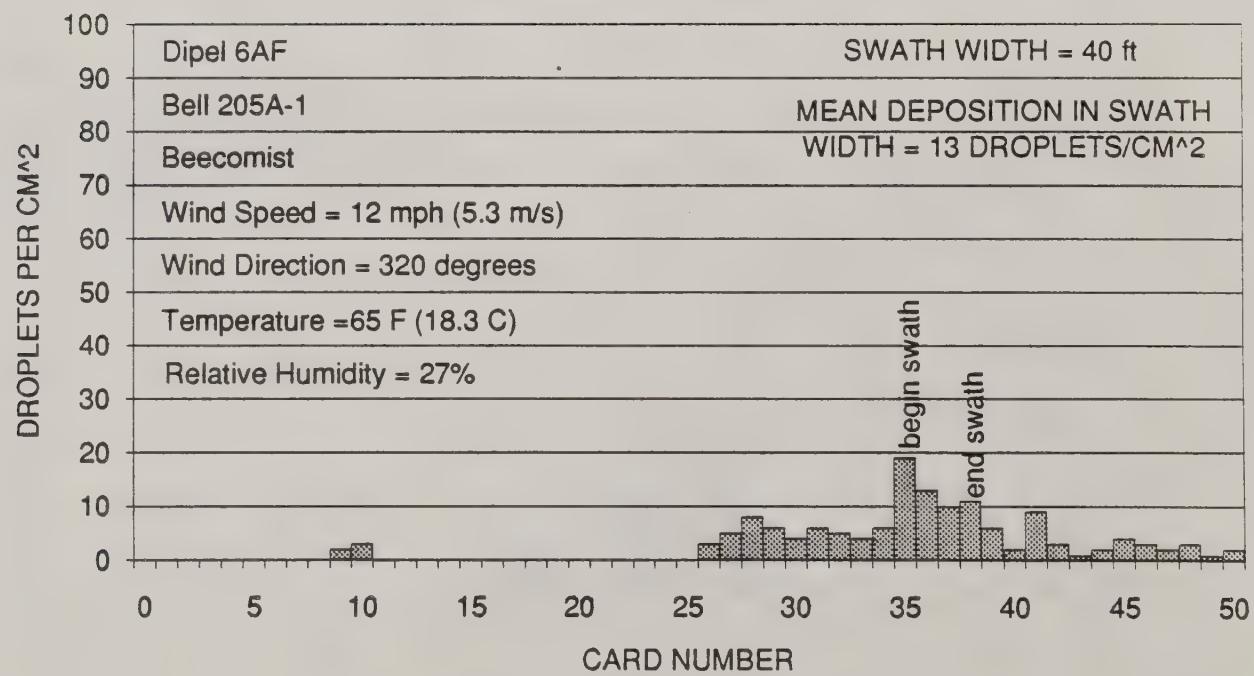
TRIAL 2 - GROUND CARD



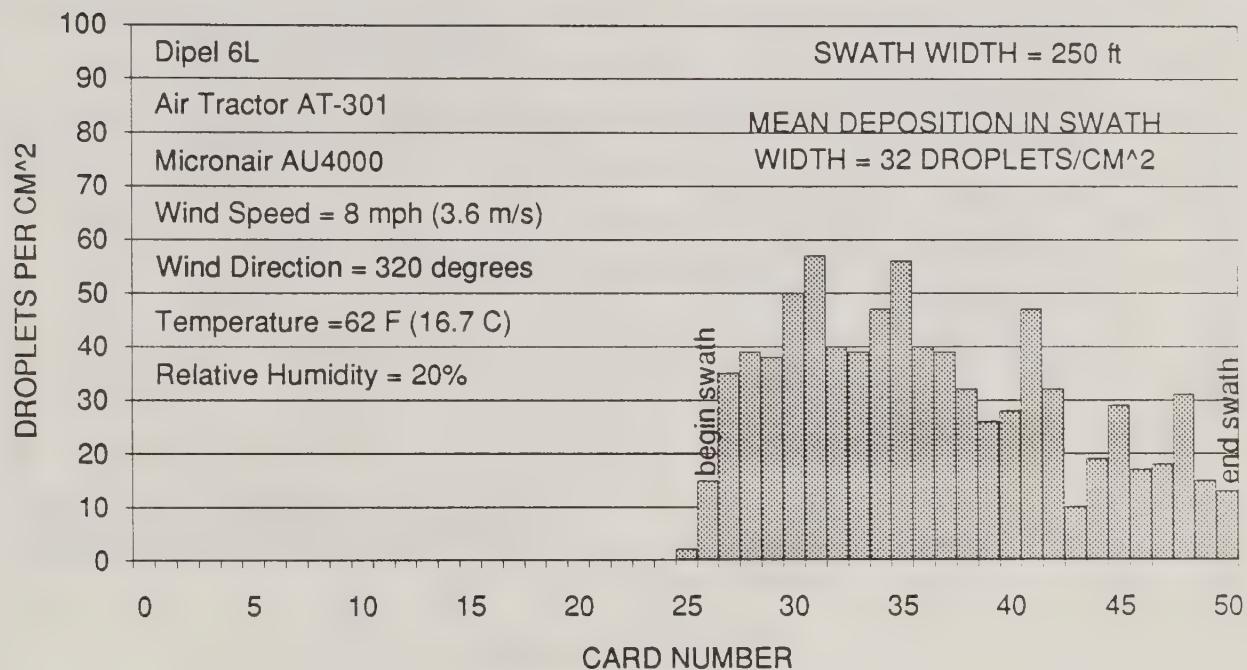
TRIAL 3 - GROUND CARD



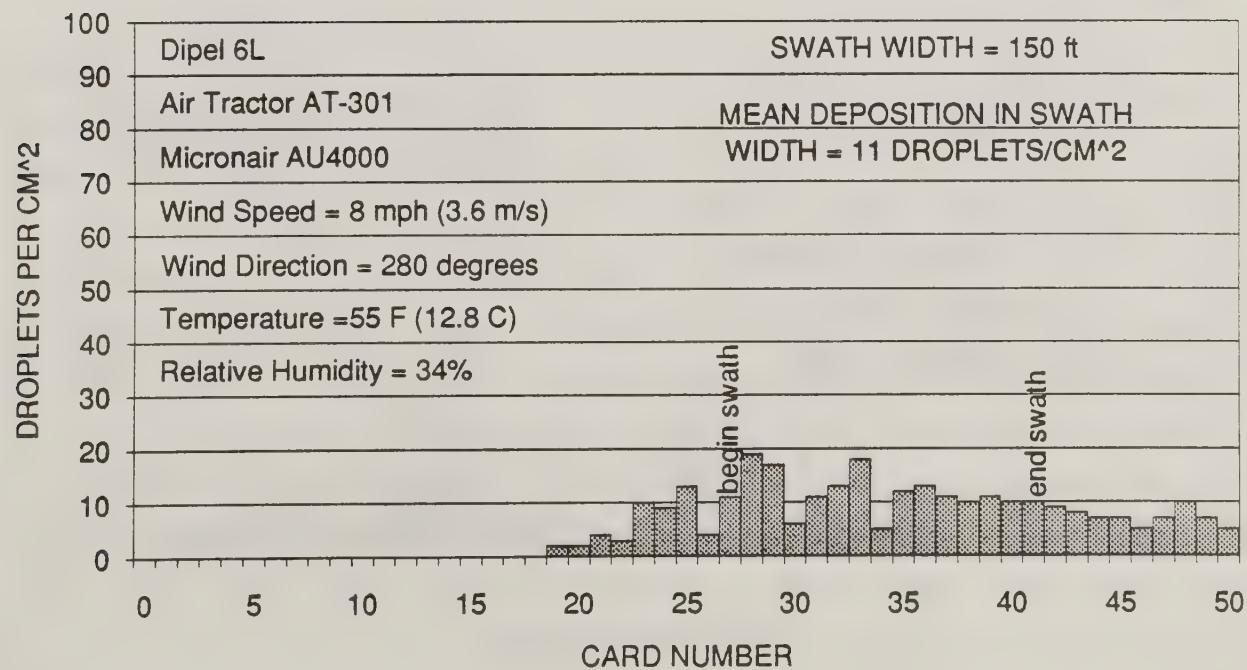
TRIAL 4 - GROUND CARD



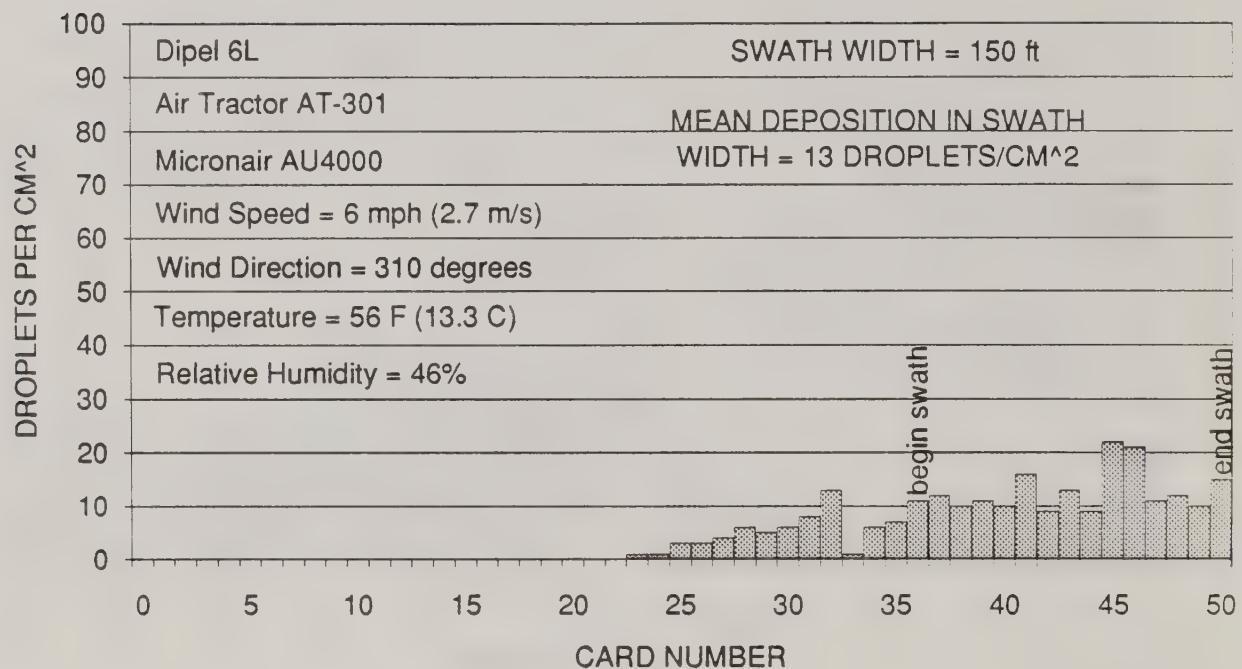
TRIAL 5 - GROUND CARD



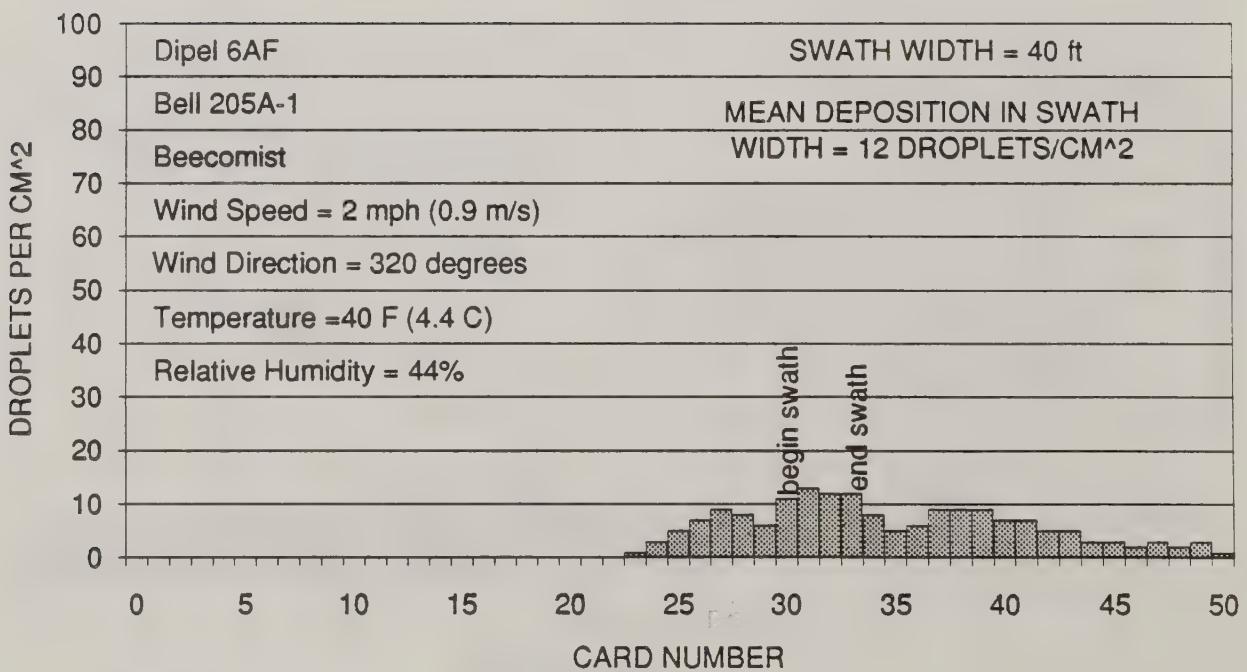
TRIAL 6 - GROUND CARD



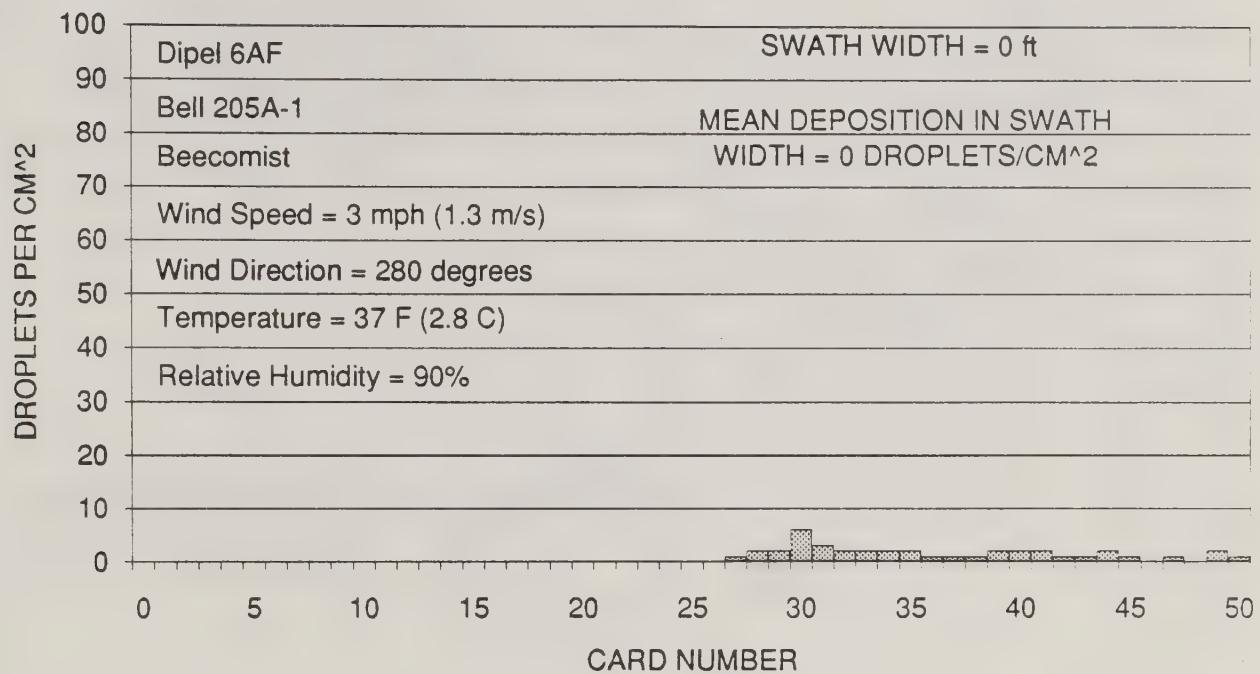
TRIAL 7 - GROUND CARD



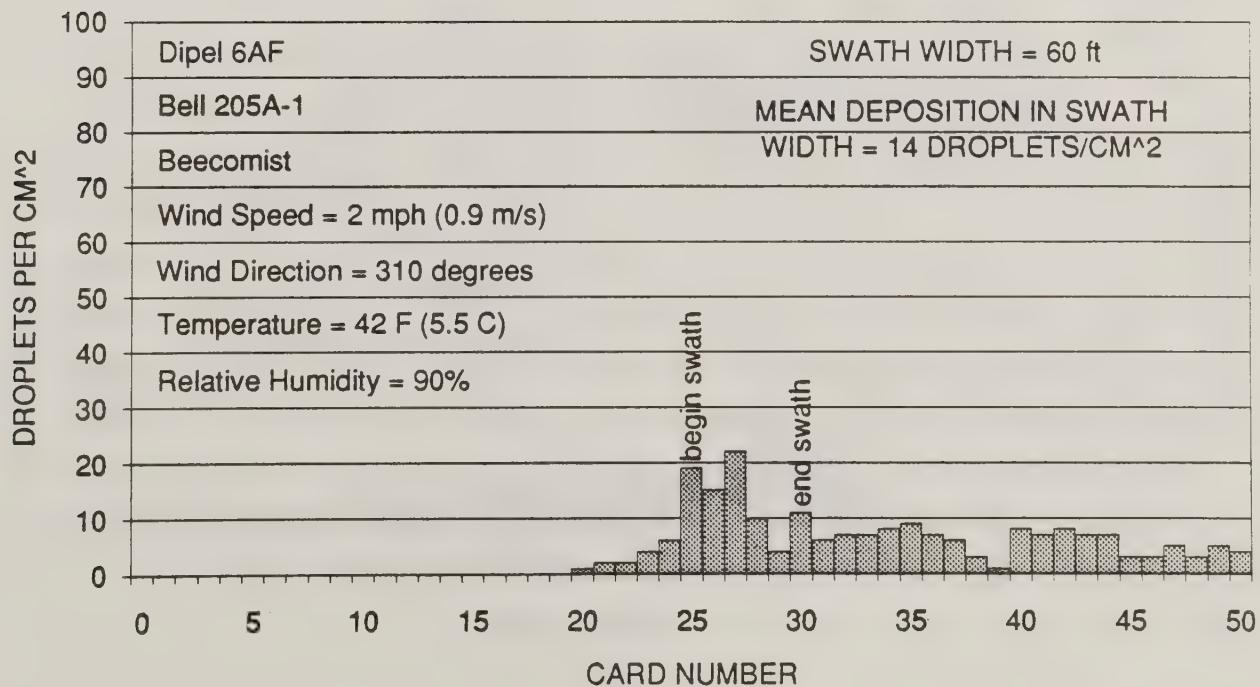
TRIAL 8 - GROUND CARD



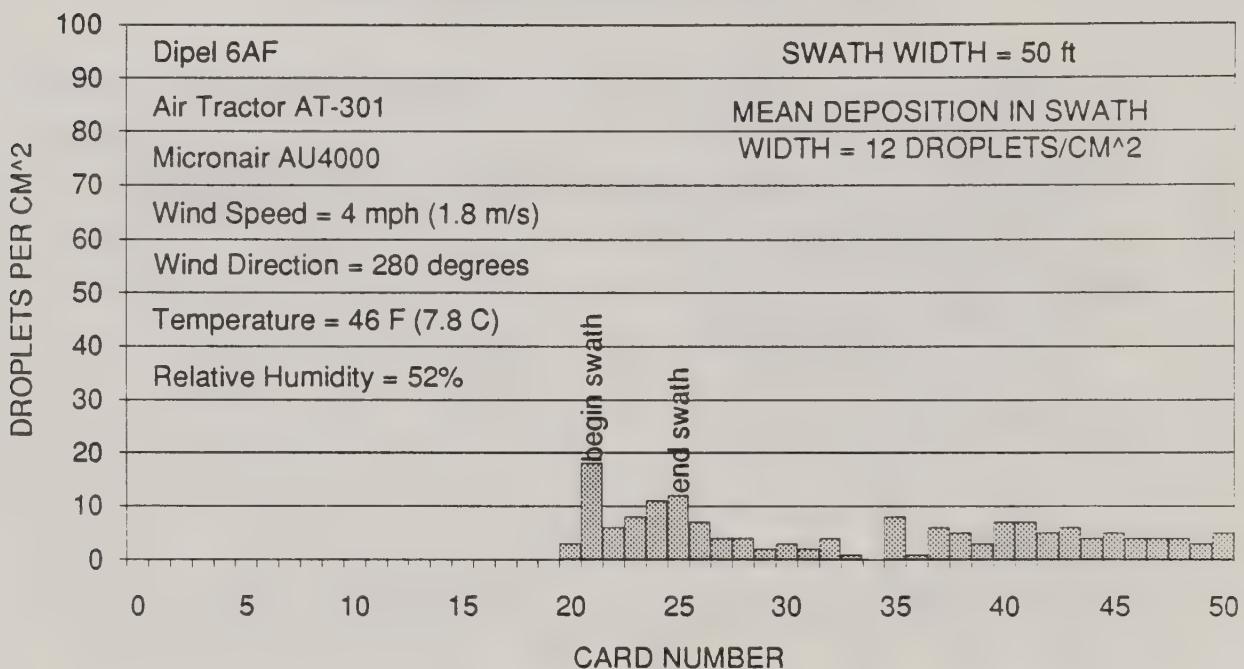
TRIAL 9 - GROUND CARD



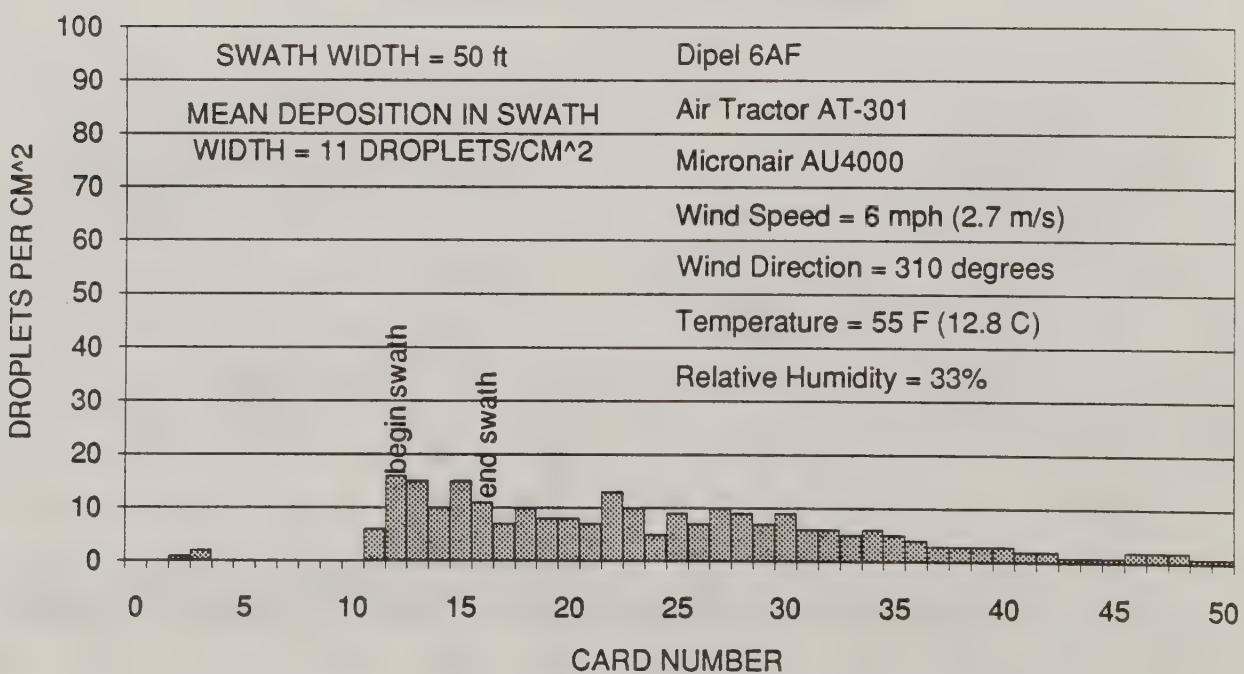
TRIAL 10 - GROUND CARD



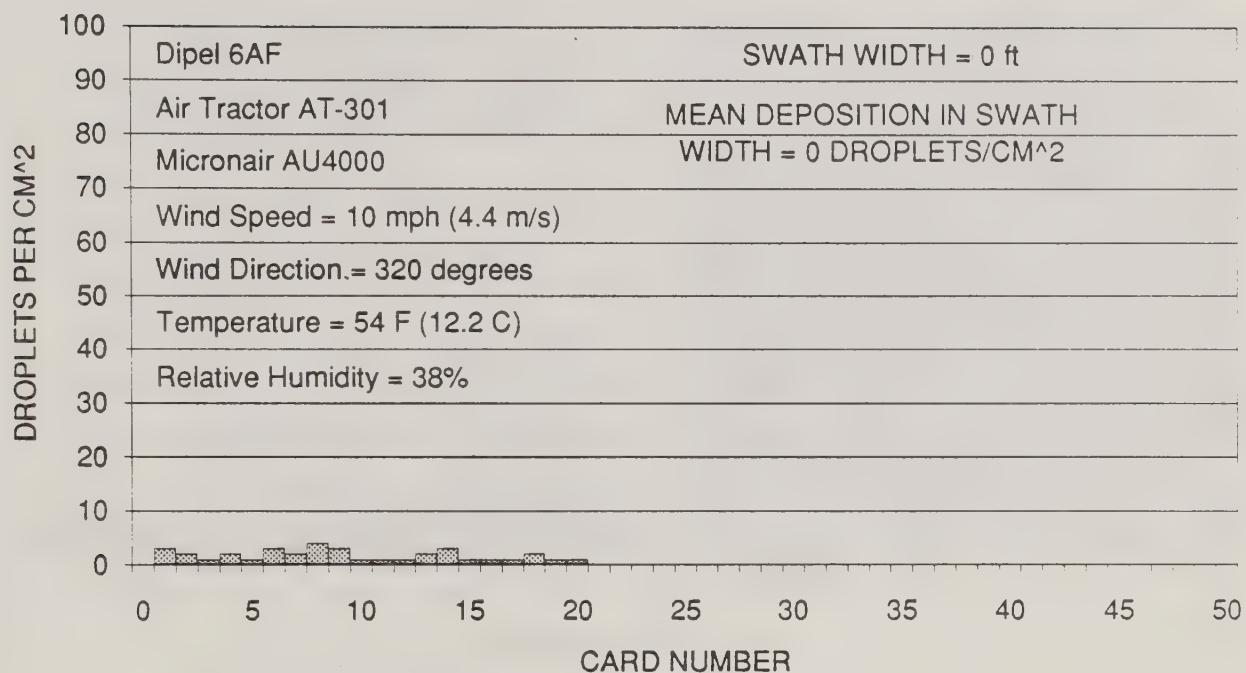
TRIAL 11 - GROUND CARD



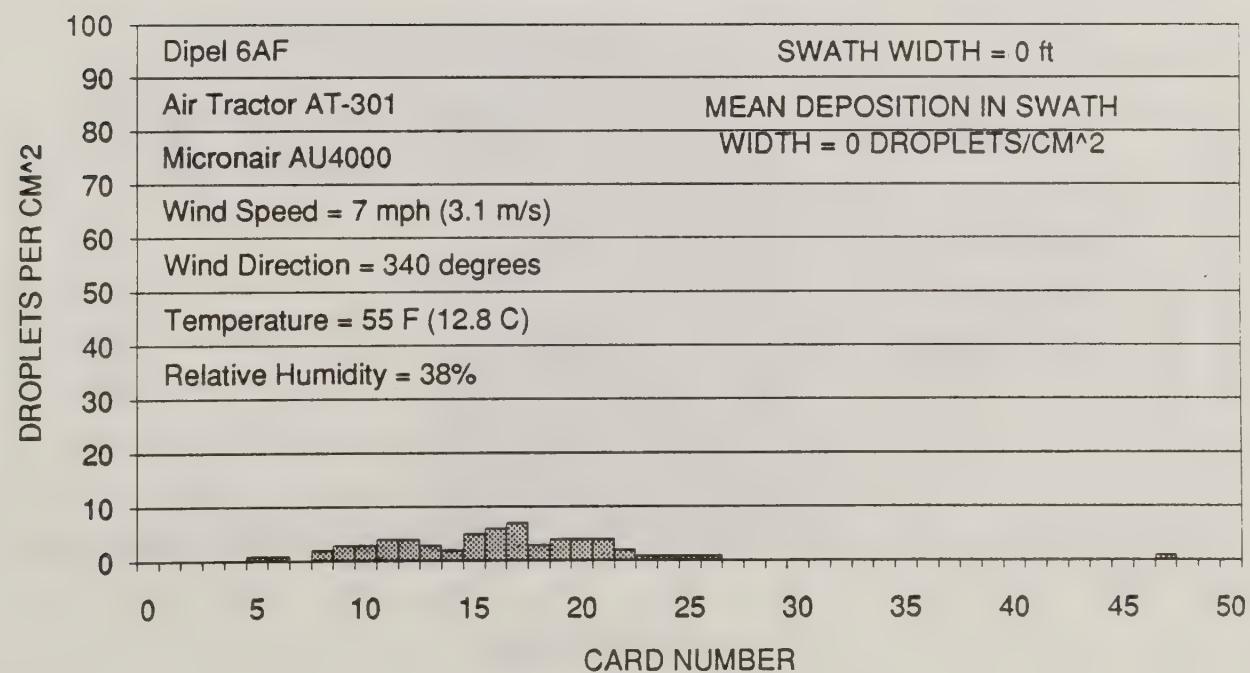
TRIAL 12 - GROUND CARD



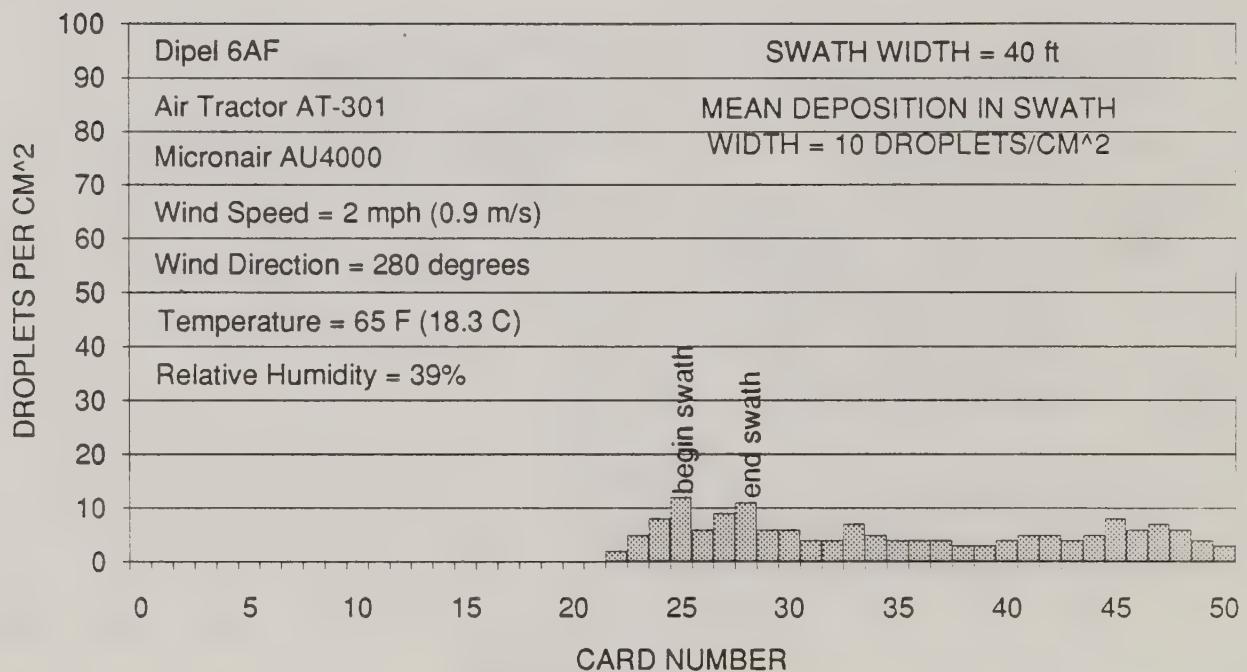
TRIAL 13 - GROUND CARD



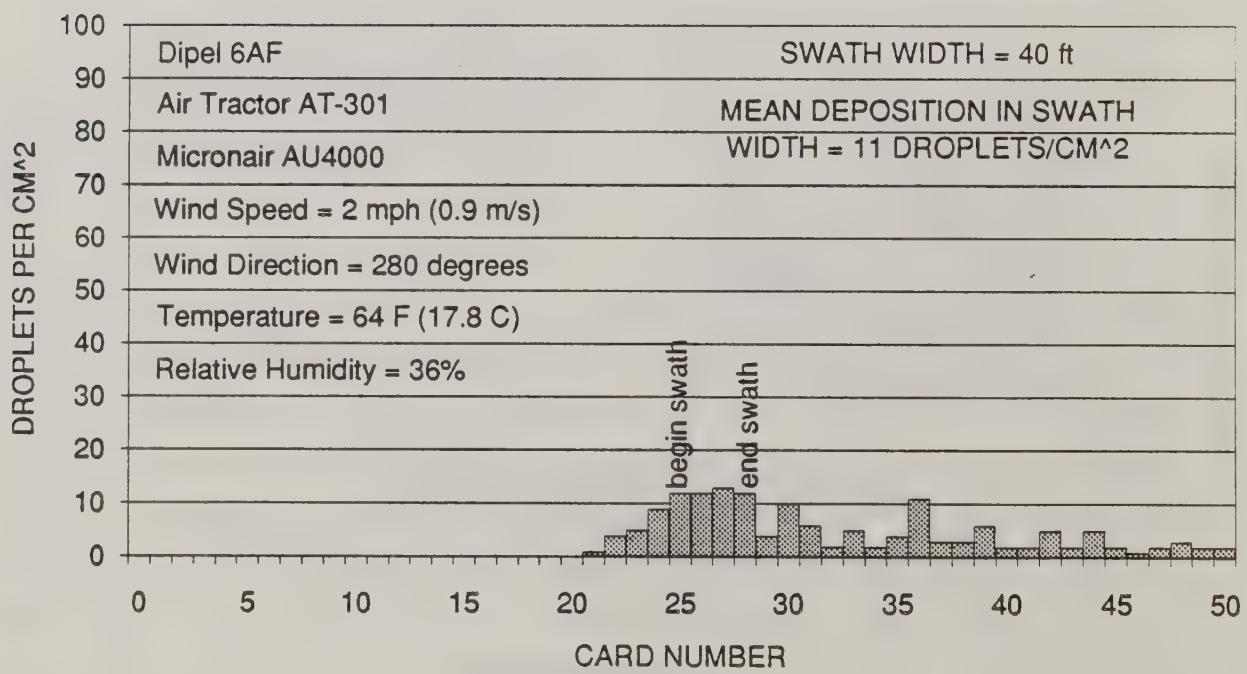
TRIAL 14 - GROUND CARD



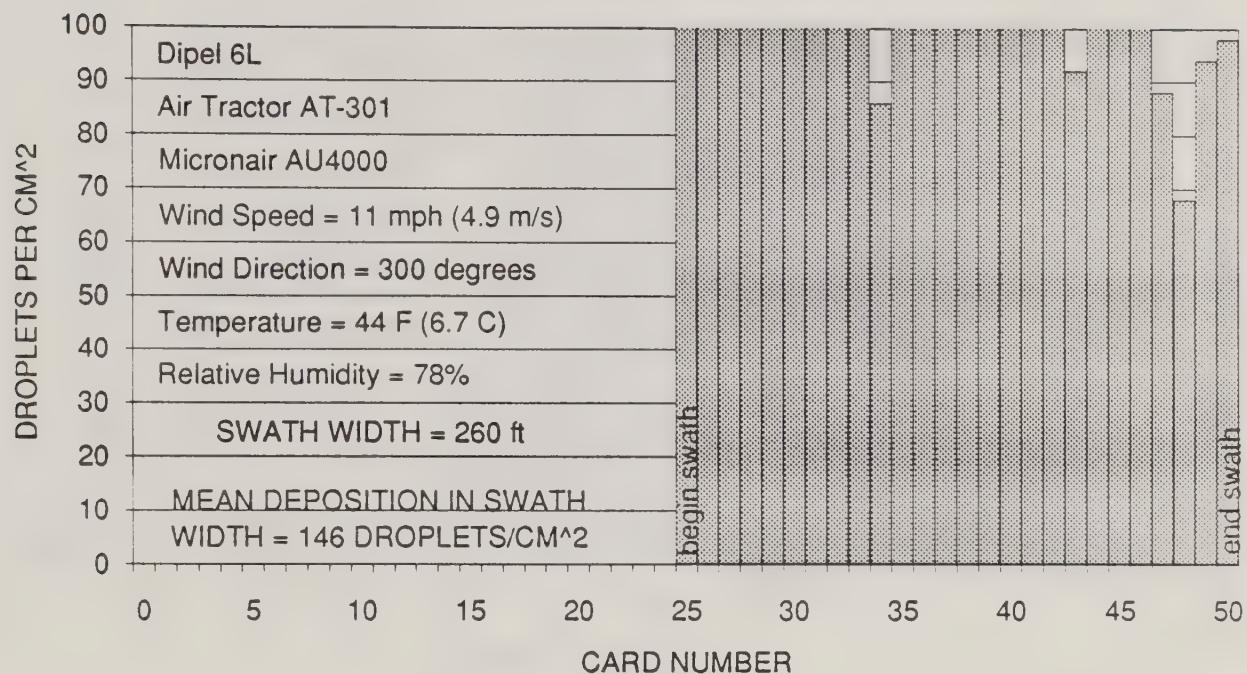
TRIAL 15 - GROUND CARD



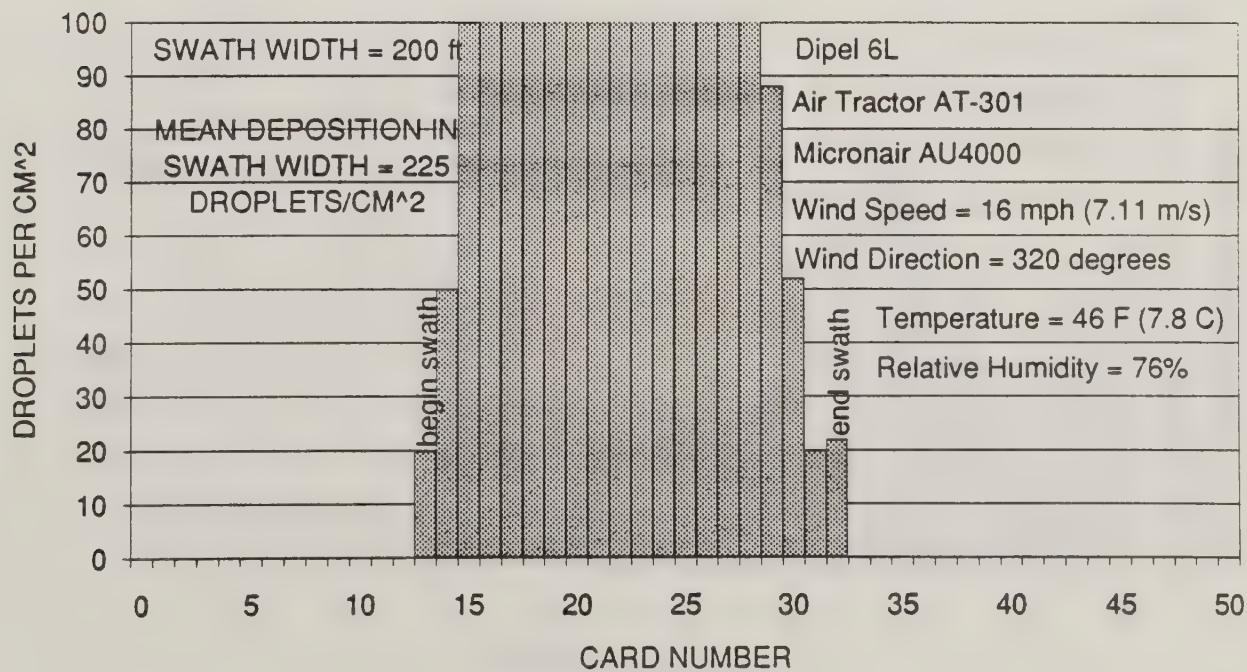
TRIAL 16 - GROUND CARD



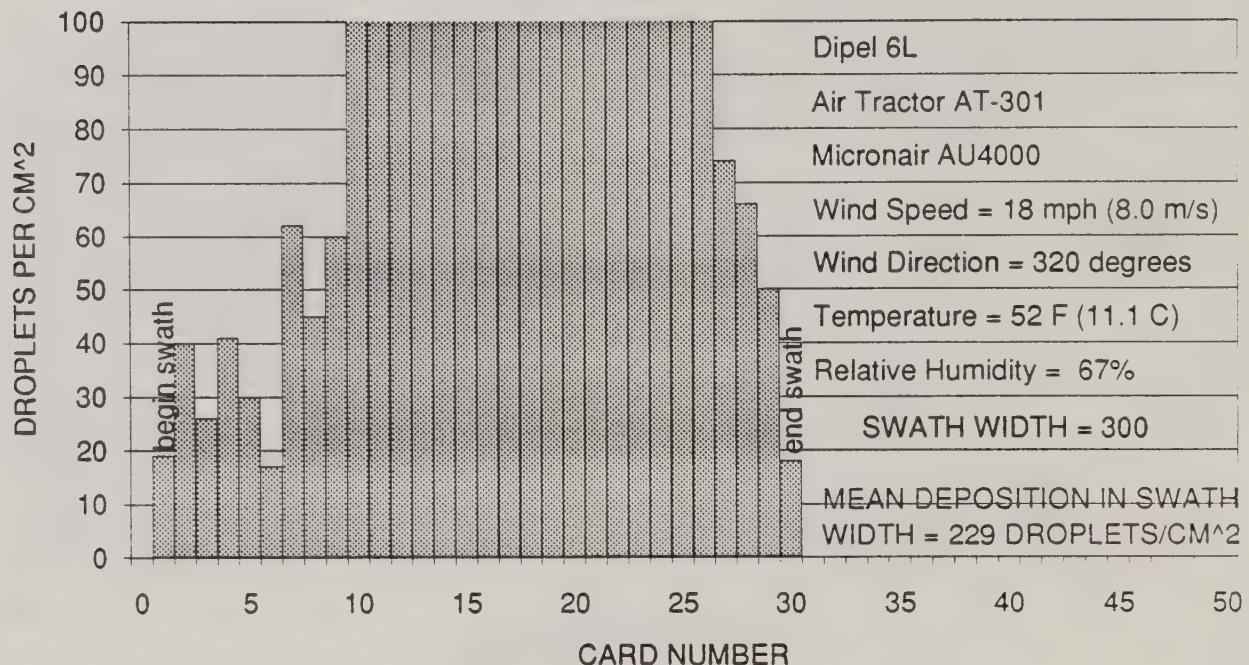
TRIAL 1 - STAKE NORTH SIDE



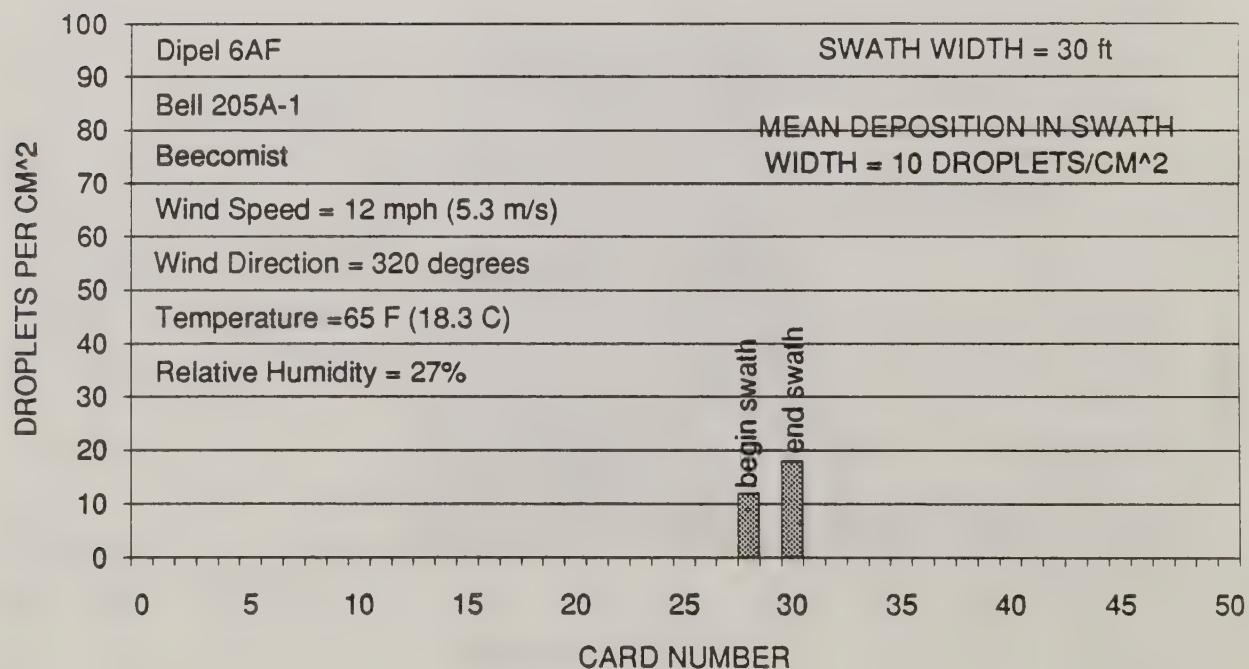
TRIAL 2 - STAKE NORTH SIDE



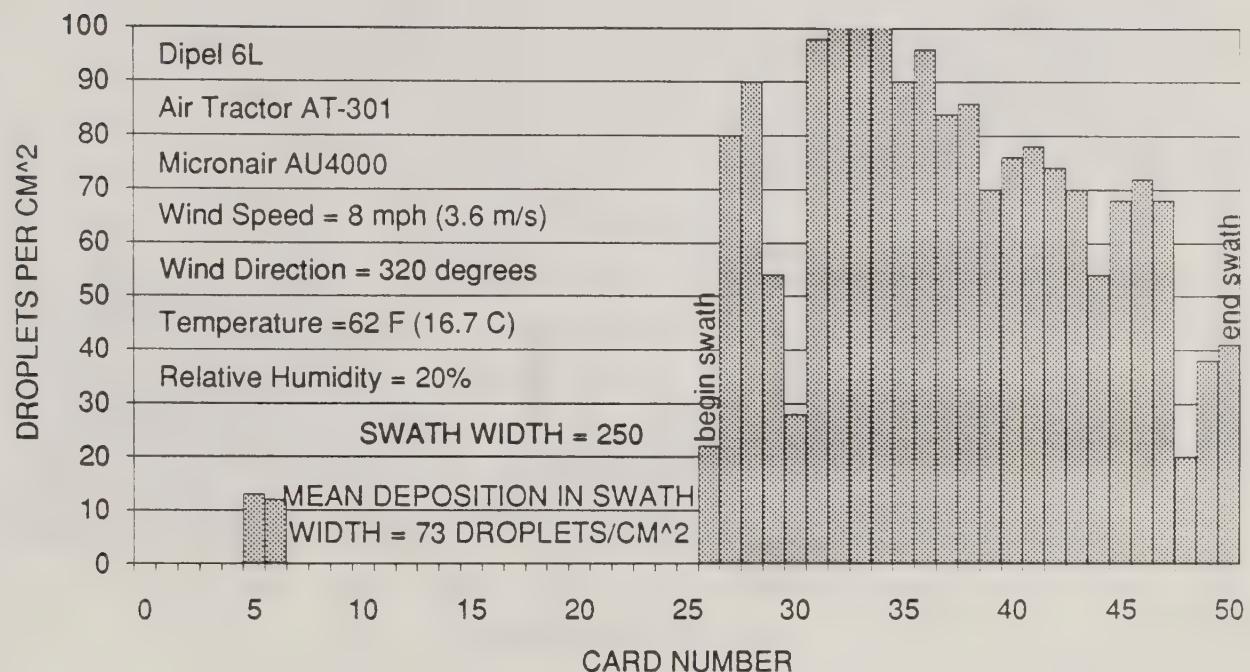
TRIAL 3 - STAKE NORTH SIDE



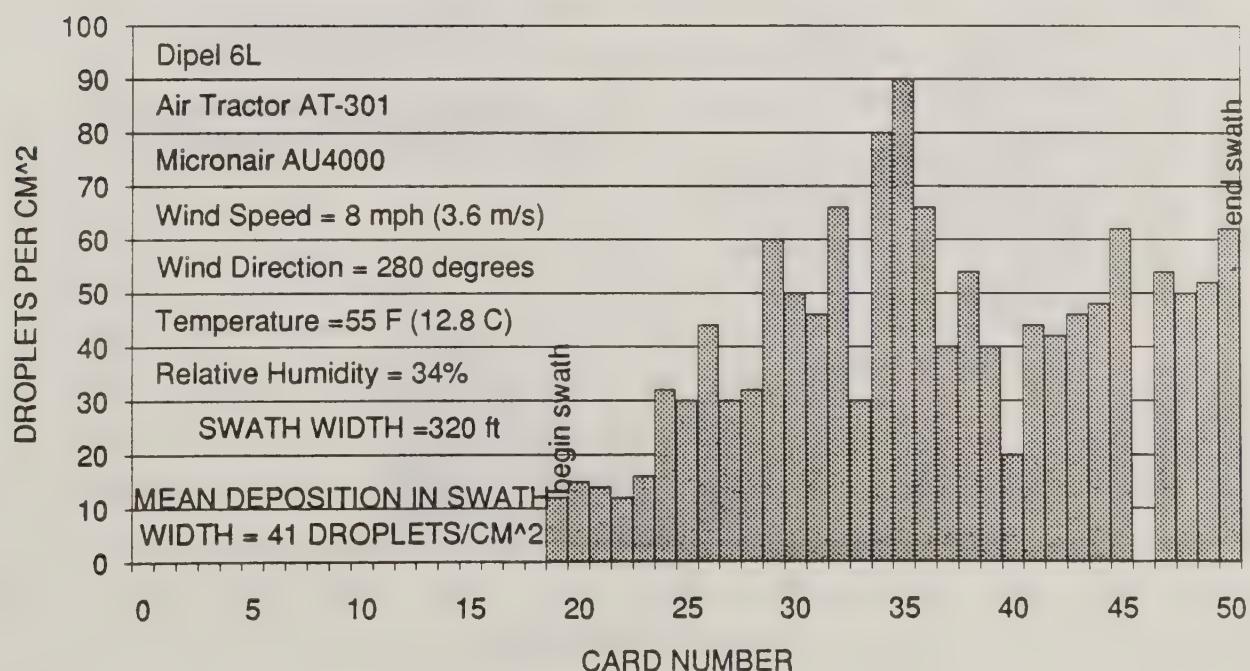
TRIAL 4 - STAKE NORTH SIDE



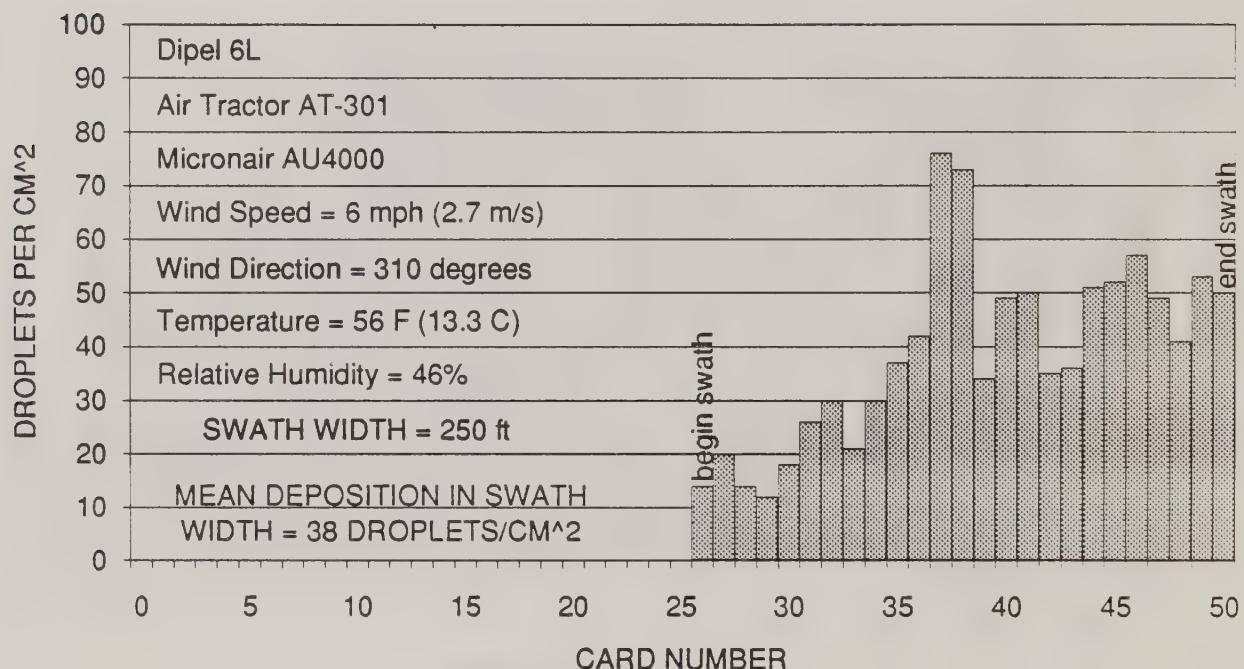
TRIAL 5 - STAKE NORTH SIDE



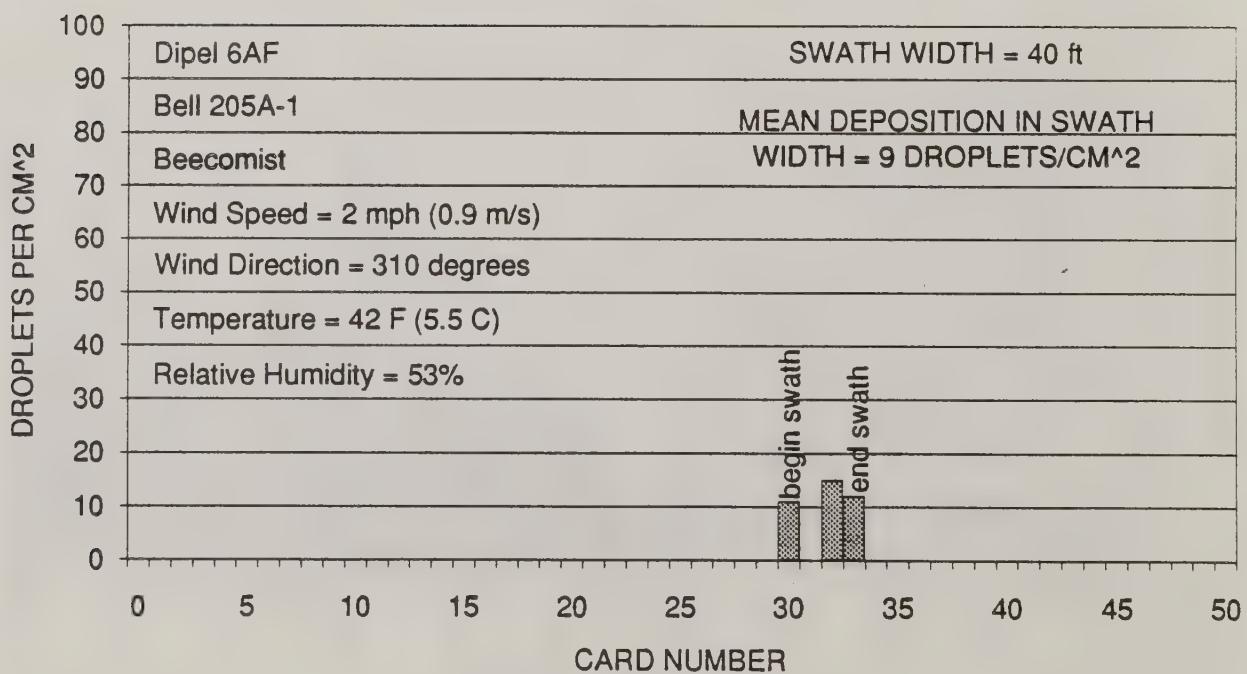
TRIAL 6 - STAKE NORTH SIDE



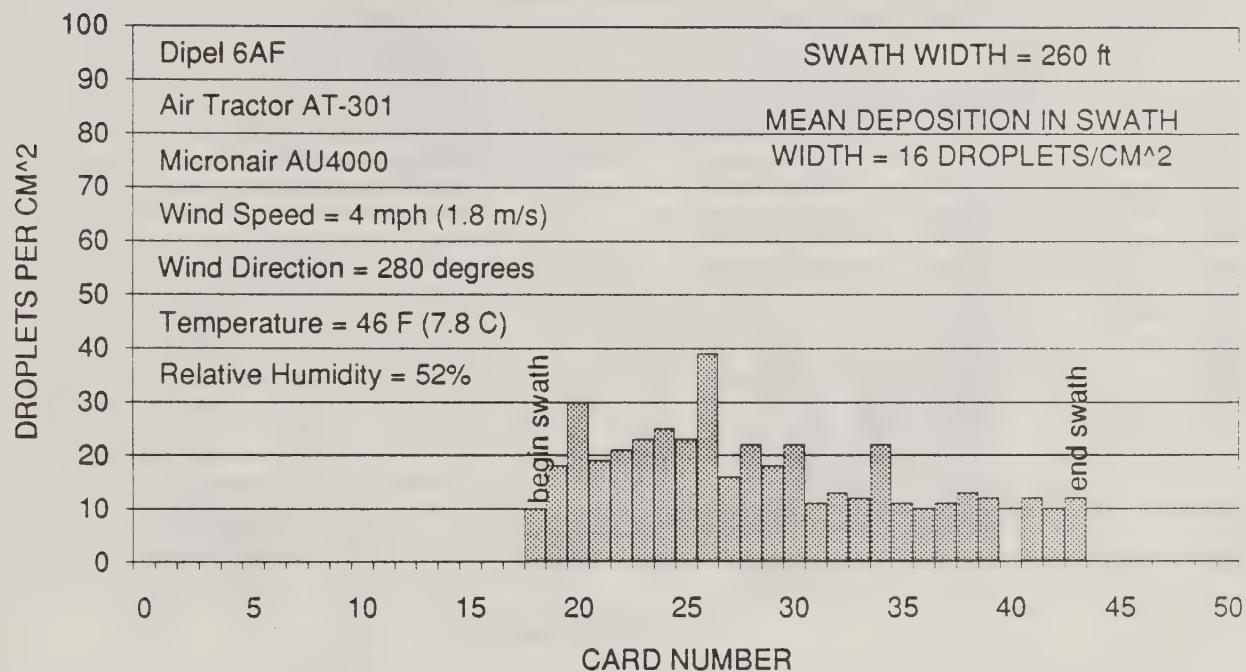
TRIAL 7 - STAKE NORTH SIDE



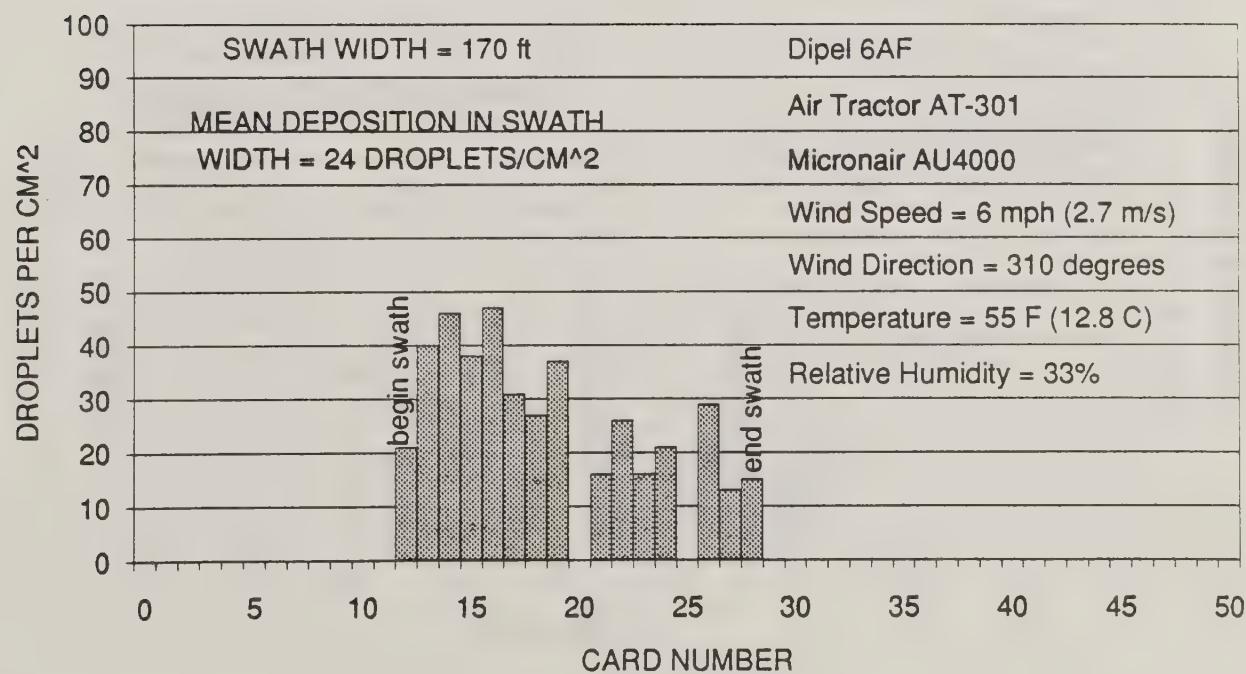
TRIAL 10 - STAKE NORTH SIDE



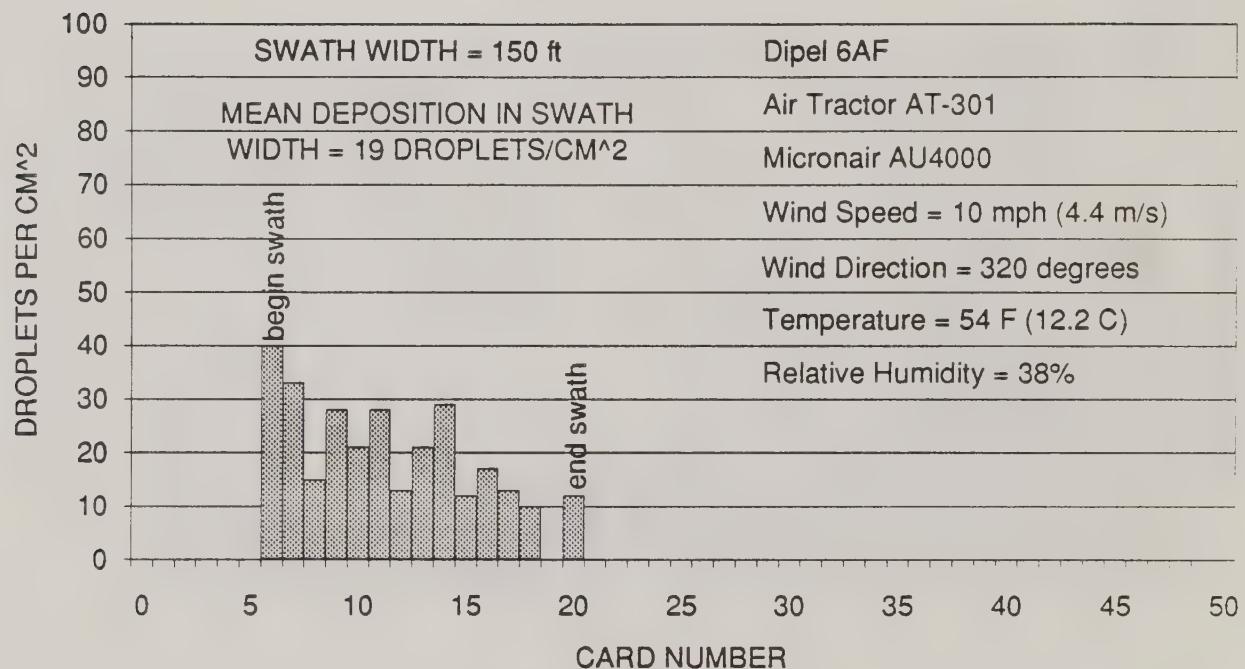
TRIAL 11 - STAKE NORTH SIDE



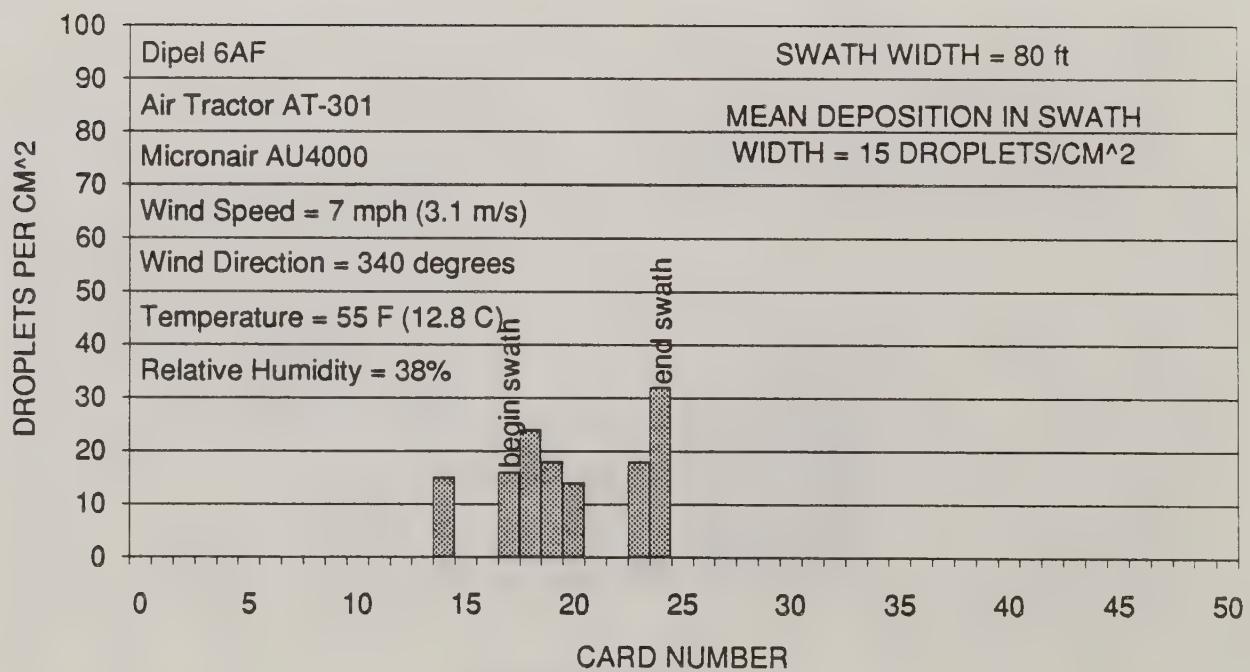
TRIAL 12 - STAKE NORTH SIDE



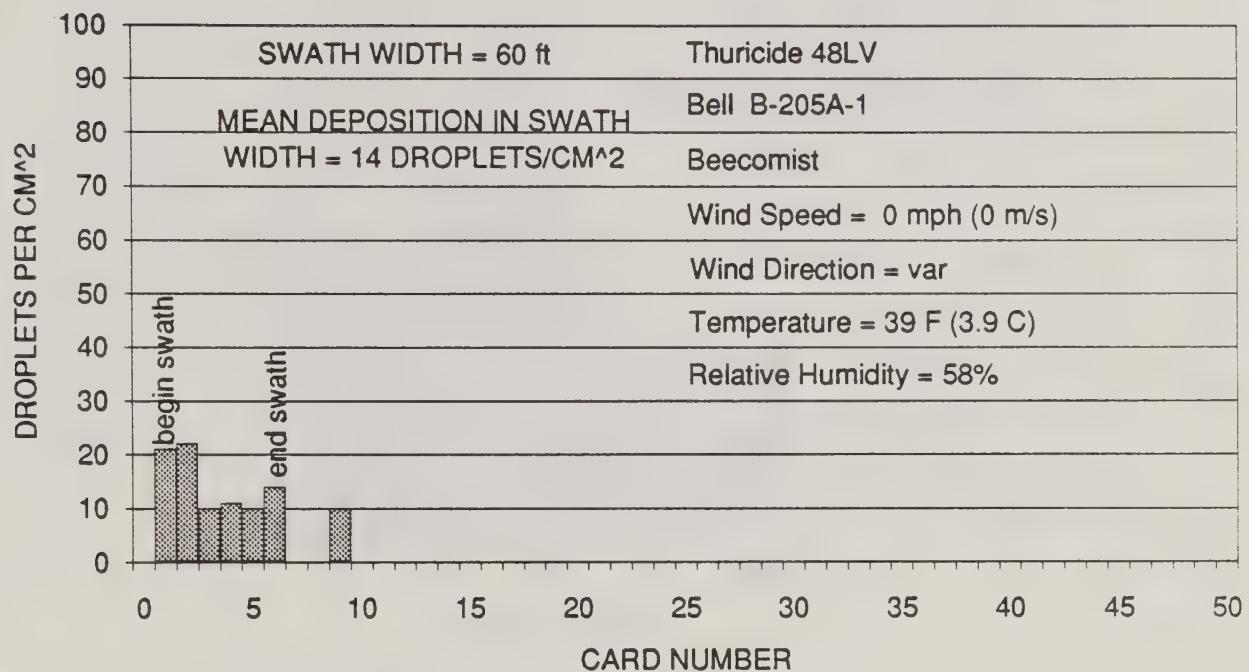
TRIAL 13 - STAKE NORTH SIDE



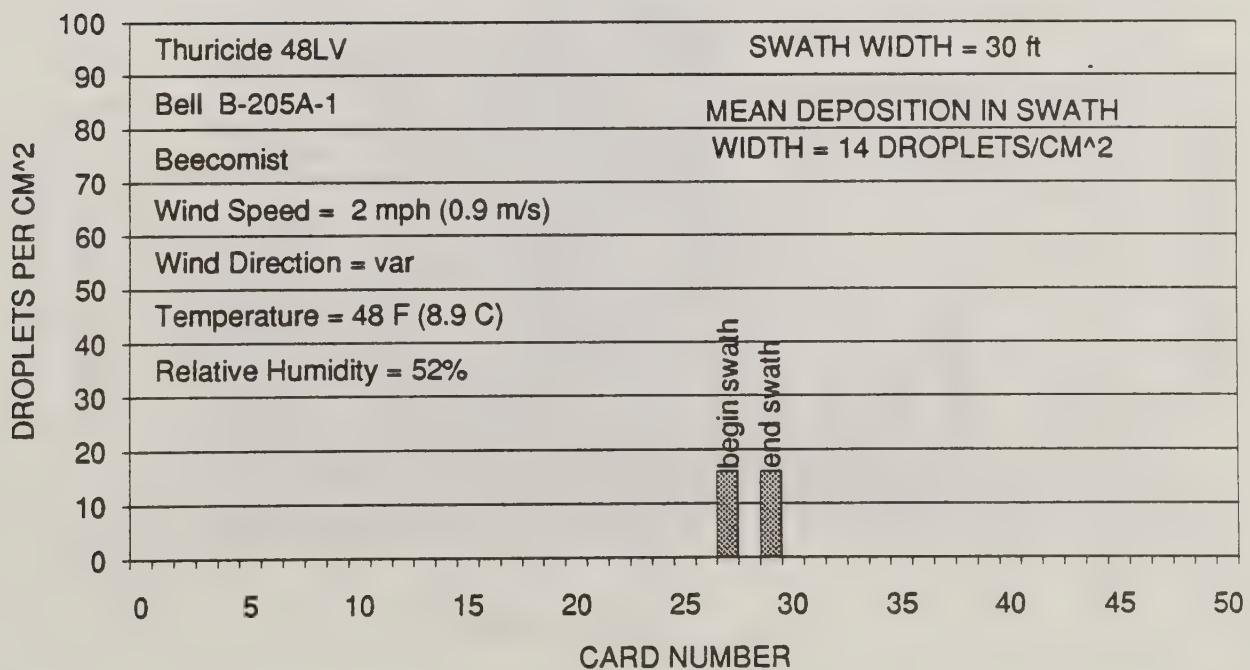
TRIAL 14 - STAKE NORTH SIDE



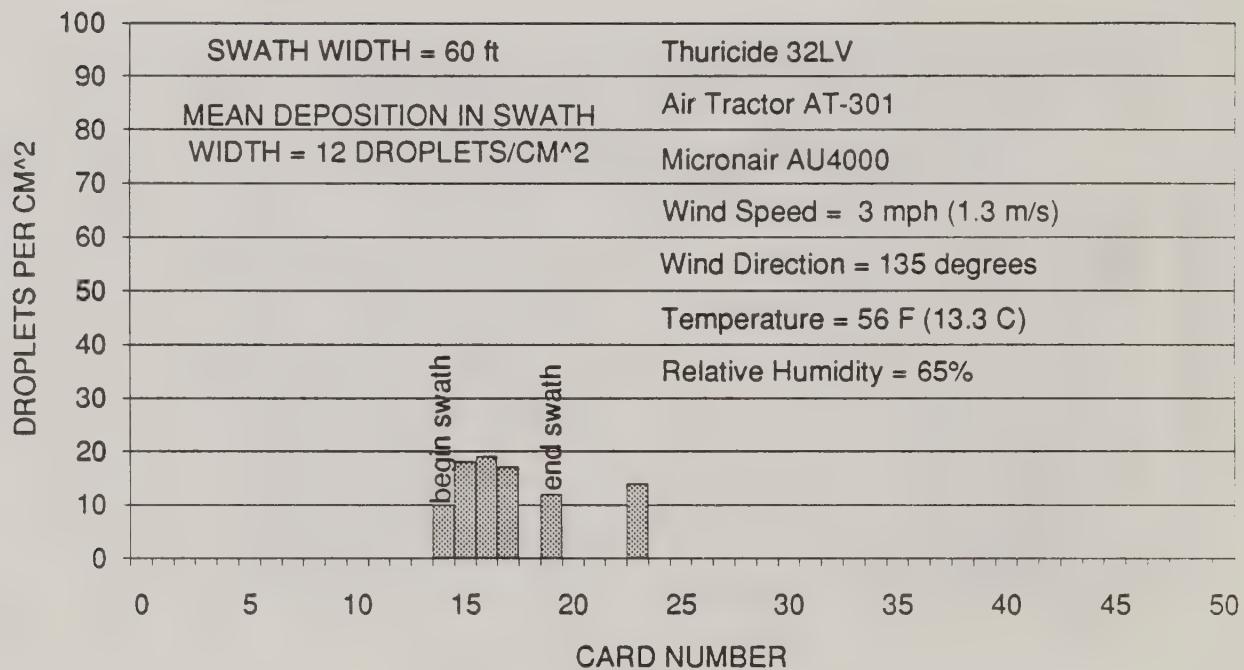
TRIAL 20 - STAKE NORTH SIDE



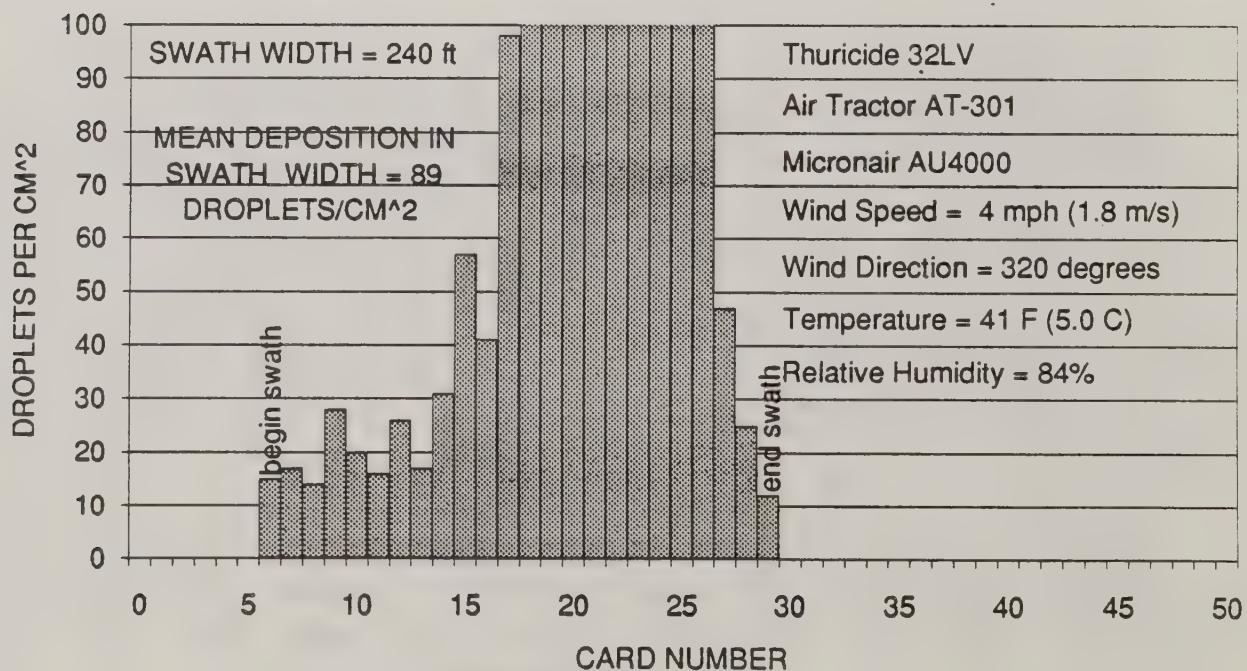
TRIAL 21 - STAKE NORTH SIDE



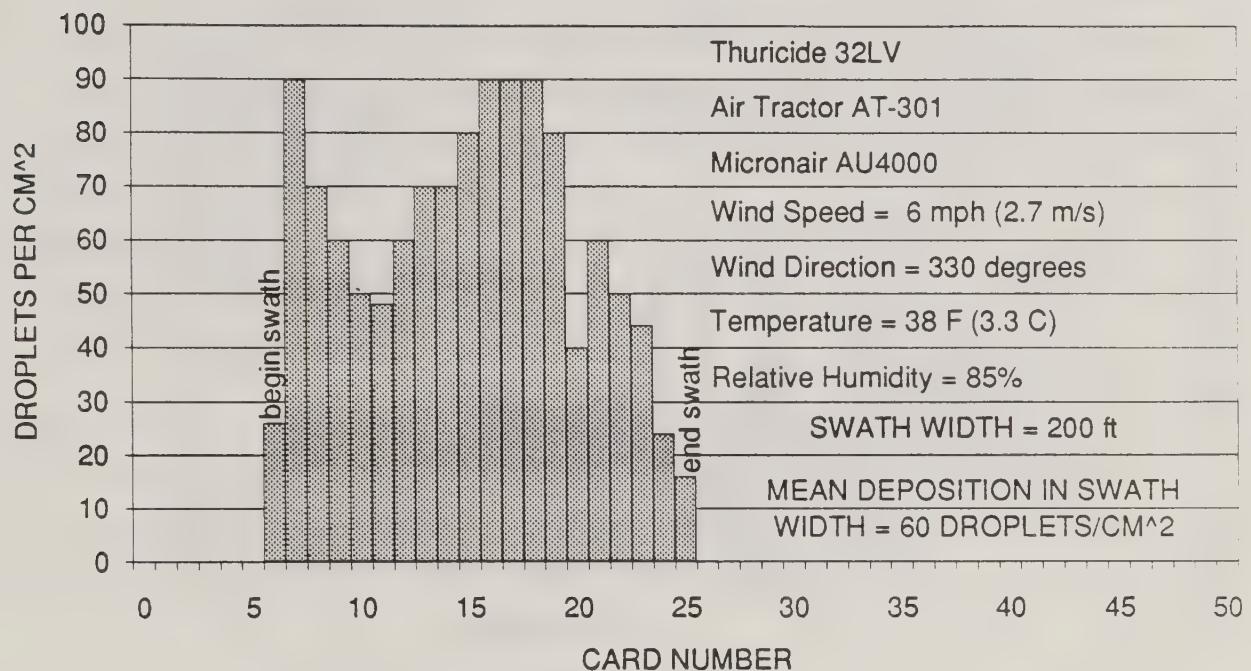
TRIAL 27 - STAKE NORTH SIDE



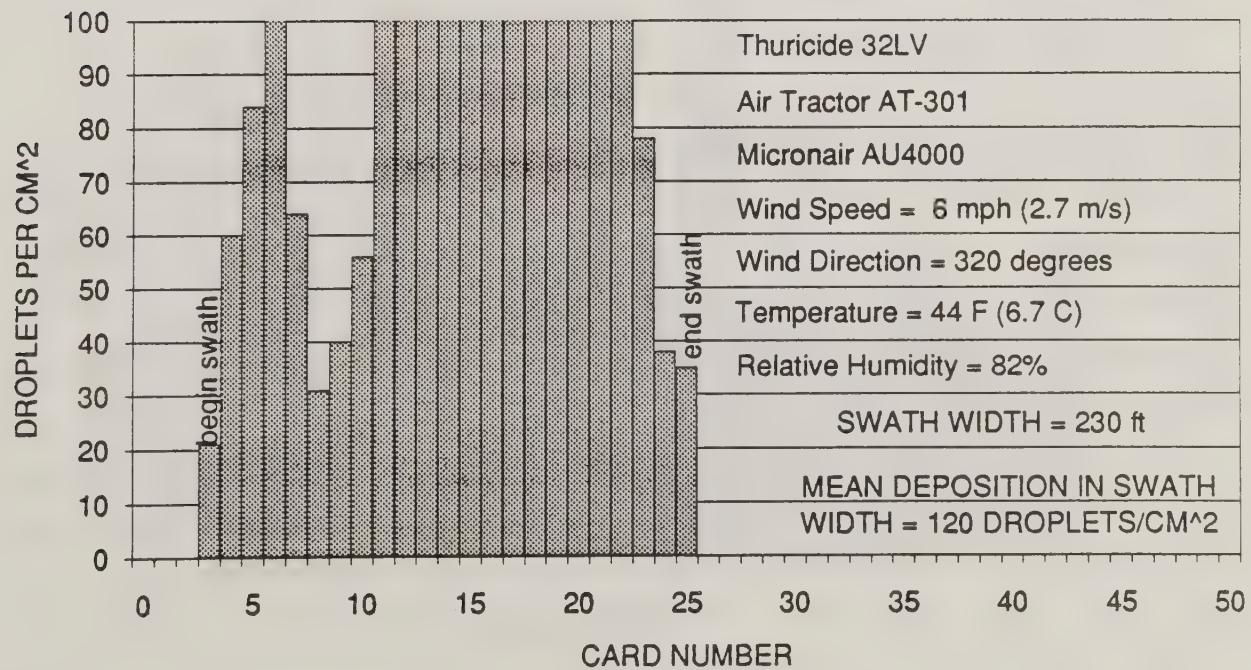
TRIAL 31 - STAKE NORTH SIDE



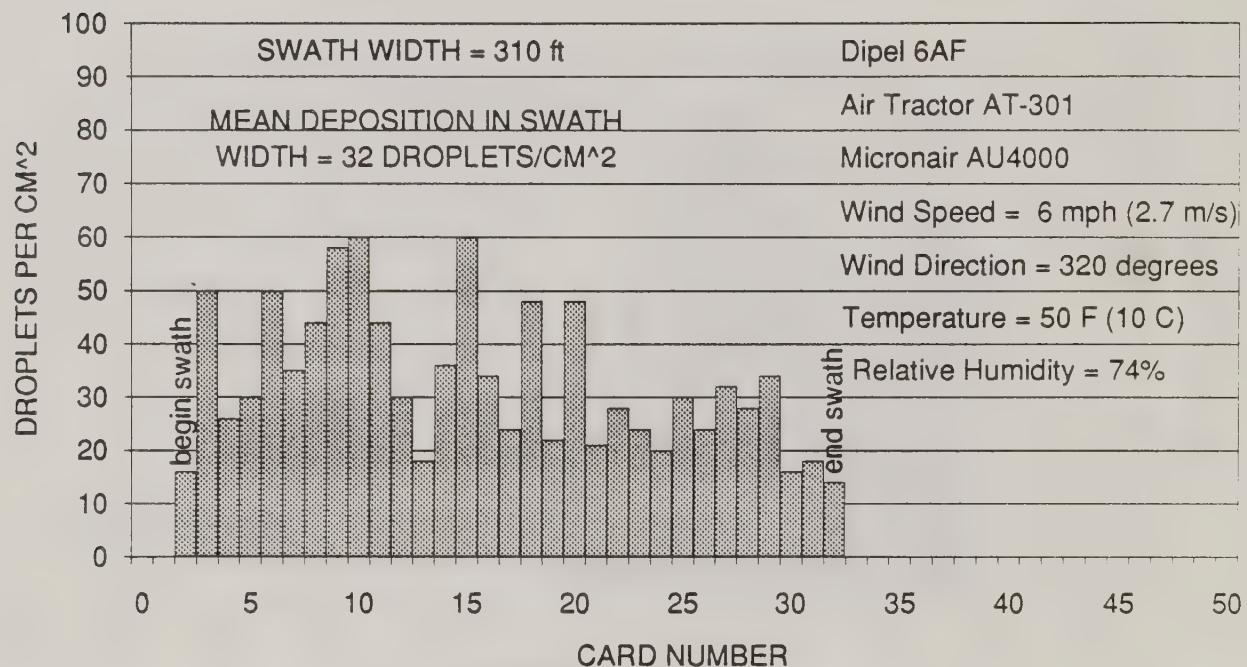
TRIAL 32 - STAKE NORTH SIDE



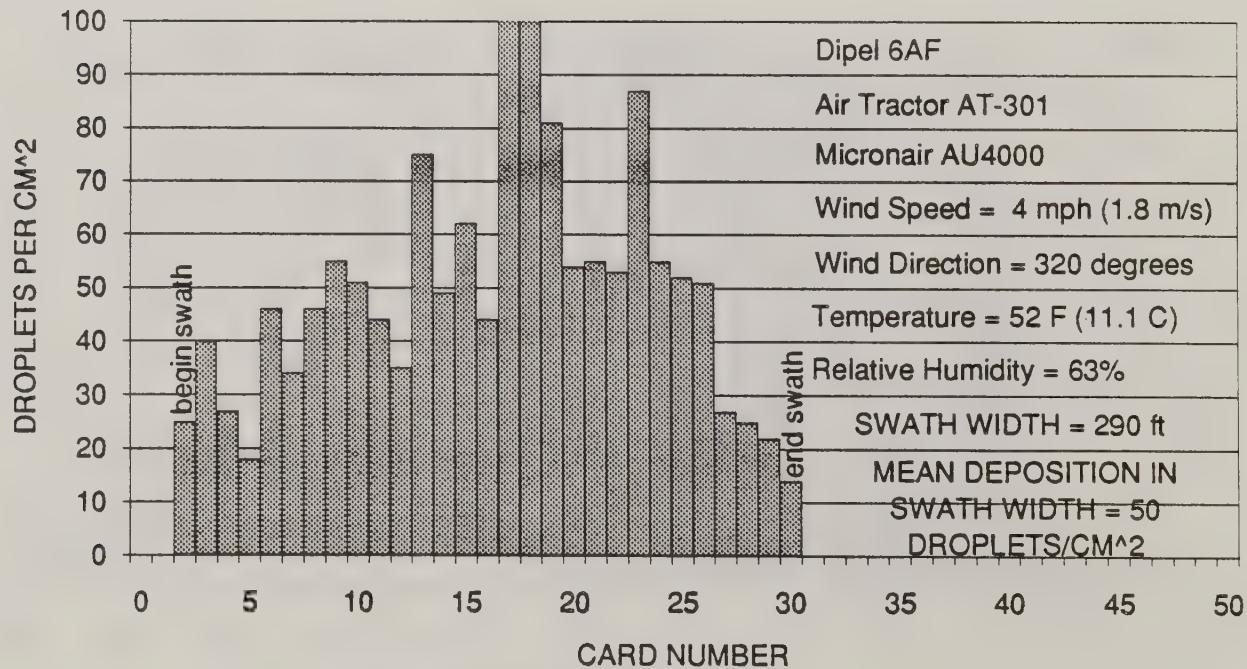
TRIAL 33 - STAKE NORTH SIDE



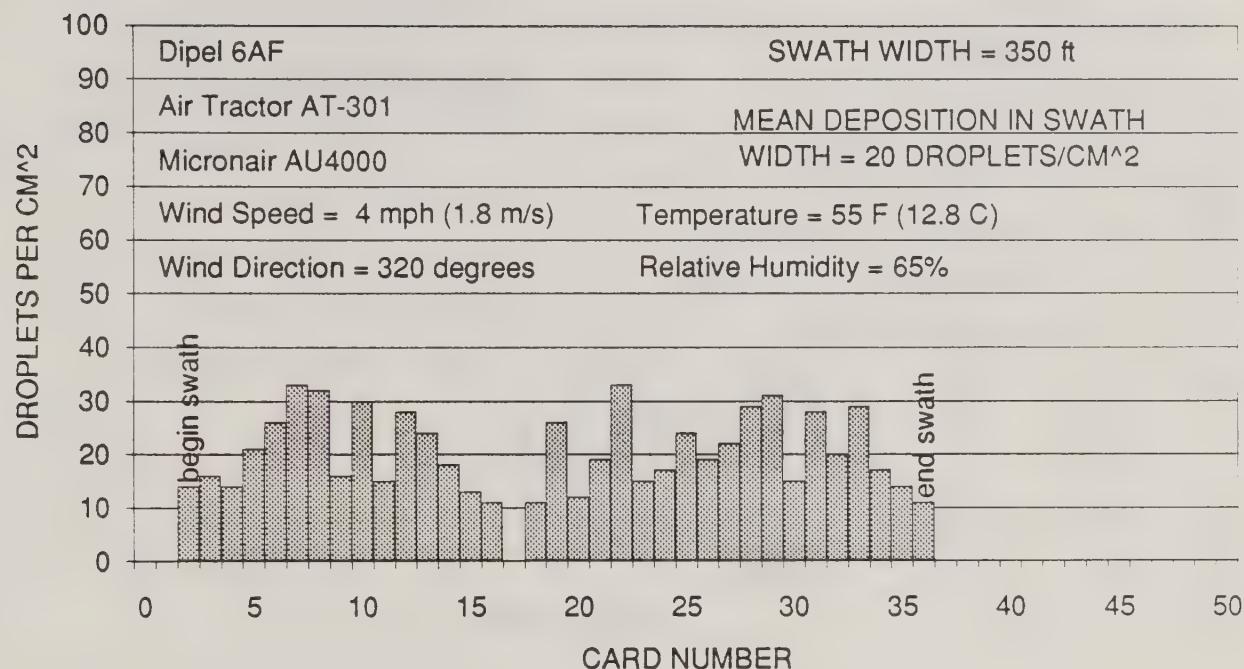
TRIAL 34 - STAKE NORTH SIDE



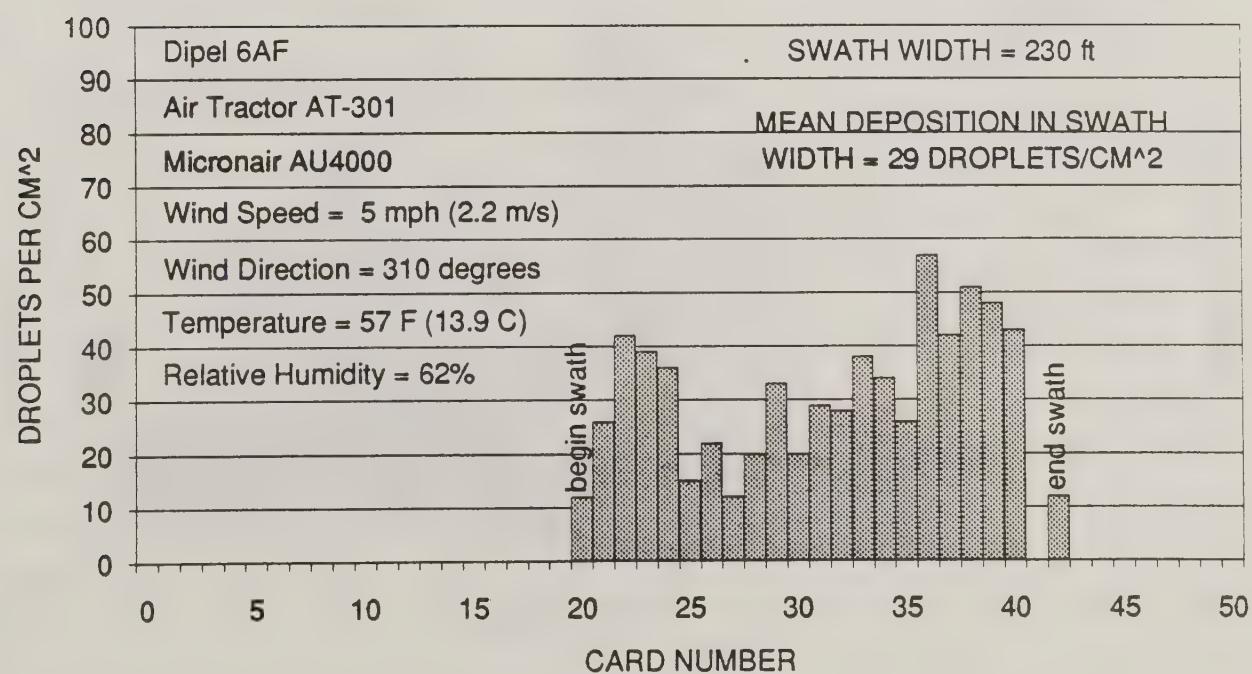
TRIAL 35 - STAKE NORTH SIDE



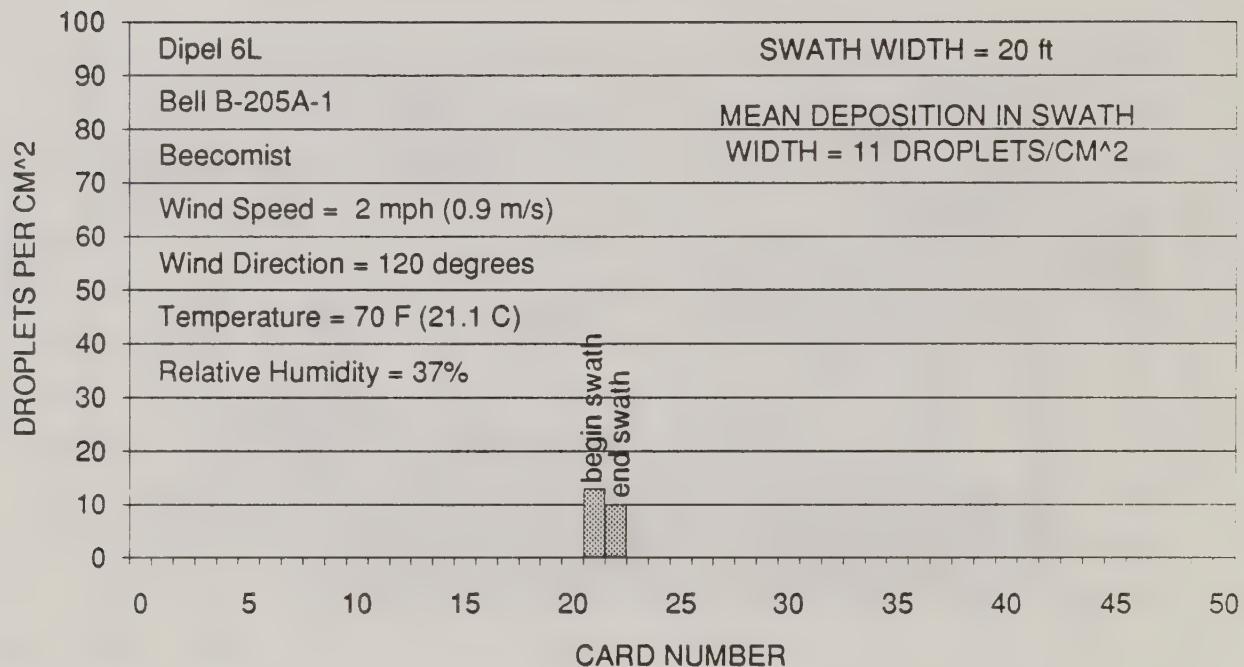
TRIAL 36 - STAKE NORTH SIDE



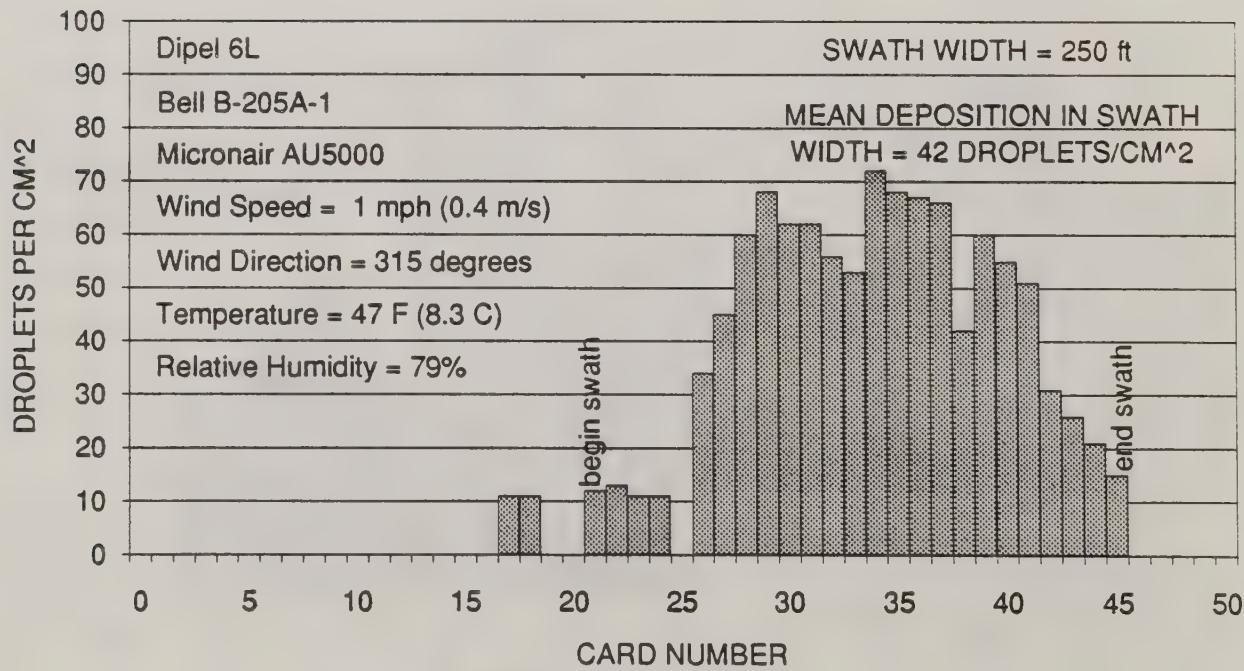
TRIAL 37 - STAKE NORTH SIDE



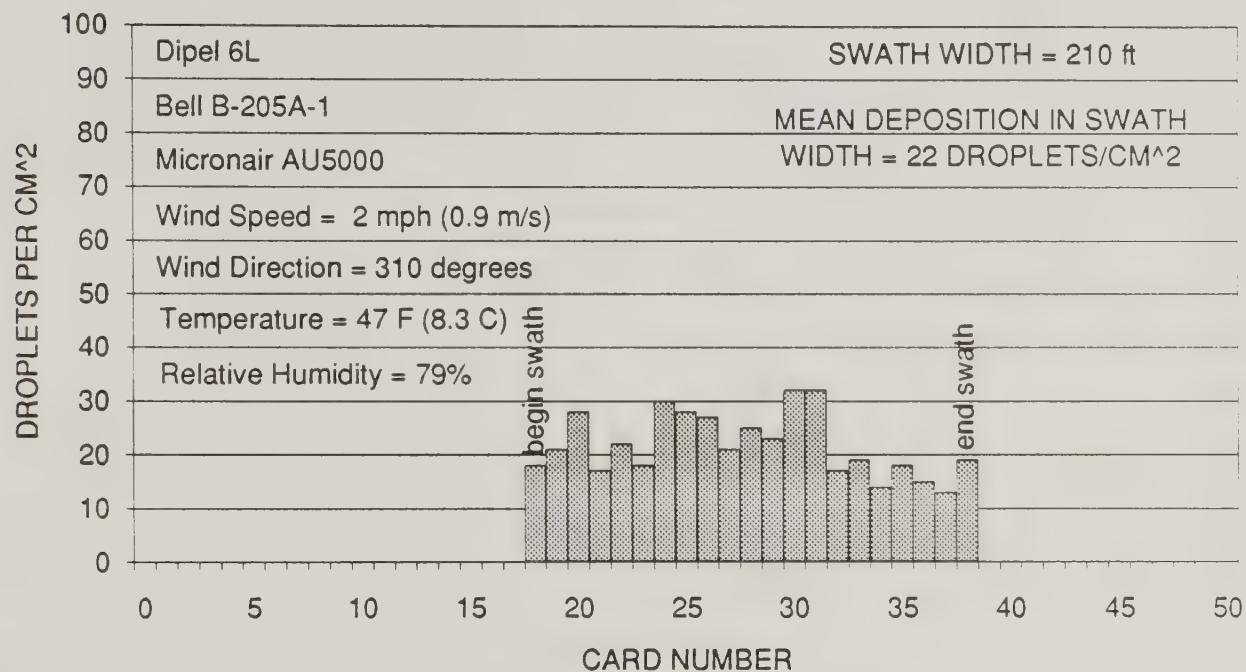
TRIAL 38 - STAKE NORTH SIDE



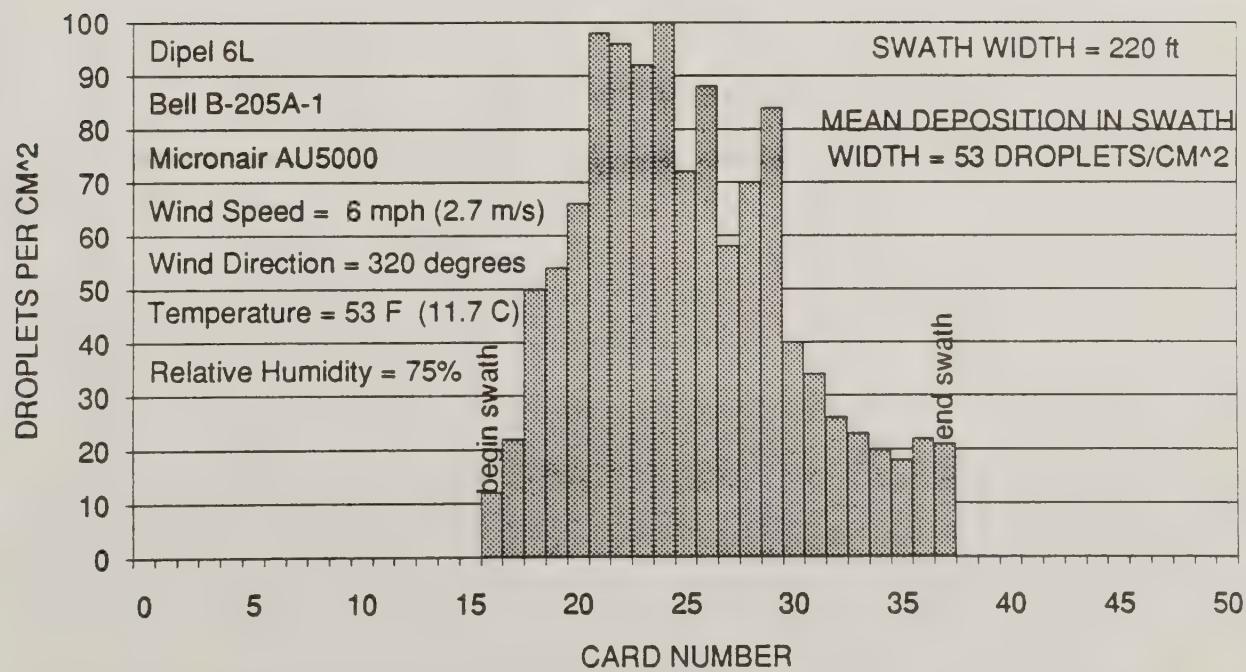
TRIAL 42 - STAKE NORTH SIDE



TRIAL 43 - STAKE NORTH SIDE



TRIAL 44 - STAKE NORTH SIDE



APPENDIX D

Trial Data and Stake South Side Deposits in Tabular and Graphical Form

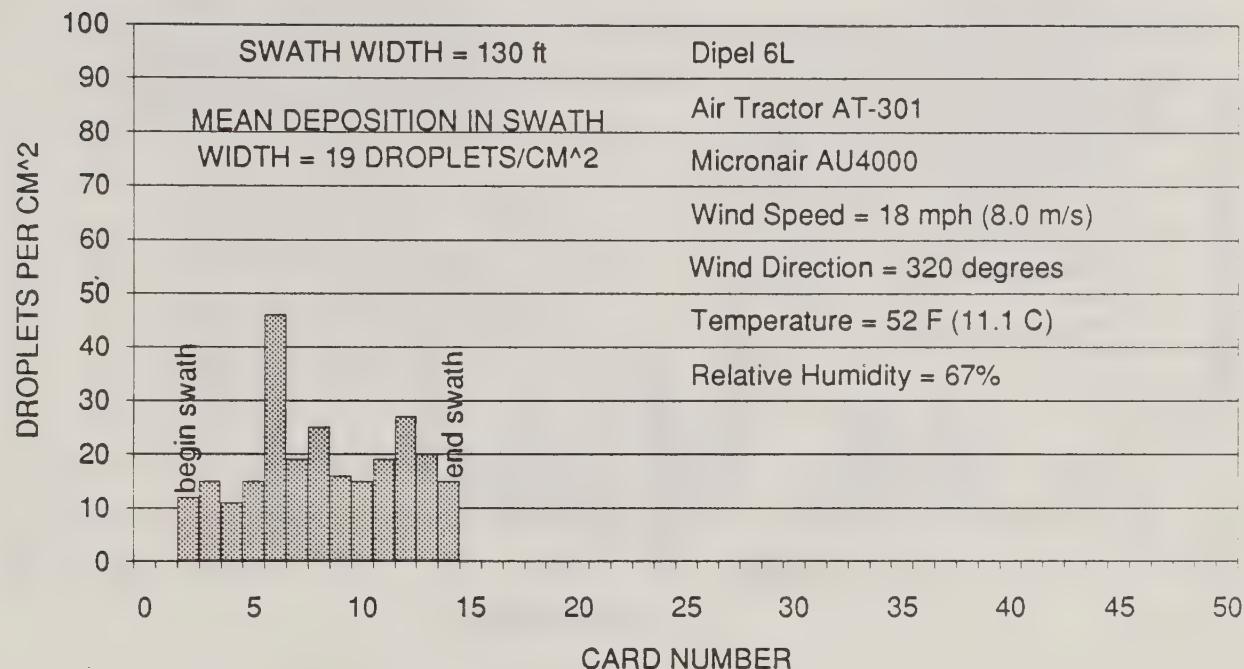
US FOREST SERVICE AIRCRAFT SPRAY CHARACTERIZATION TRIALS

MARCH 1988

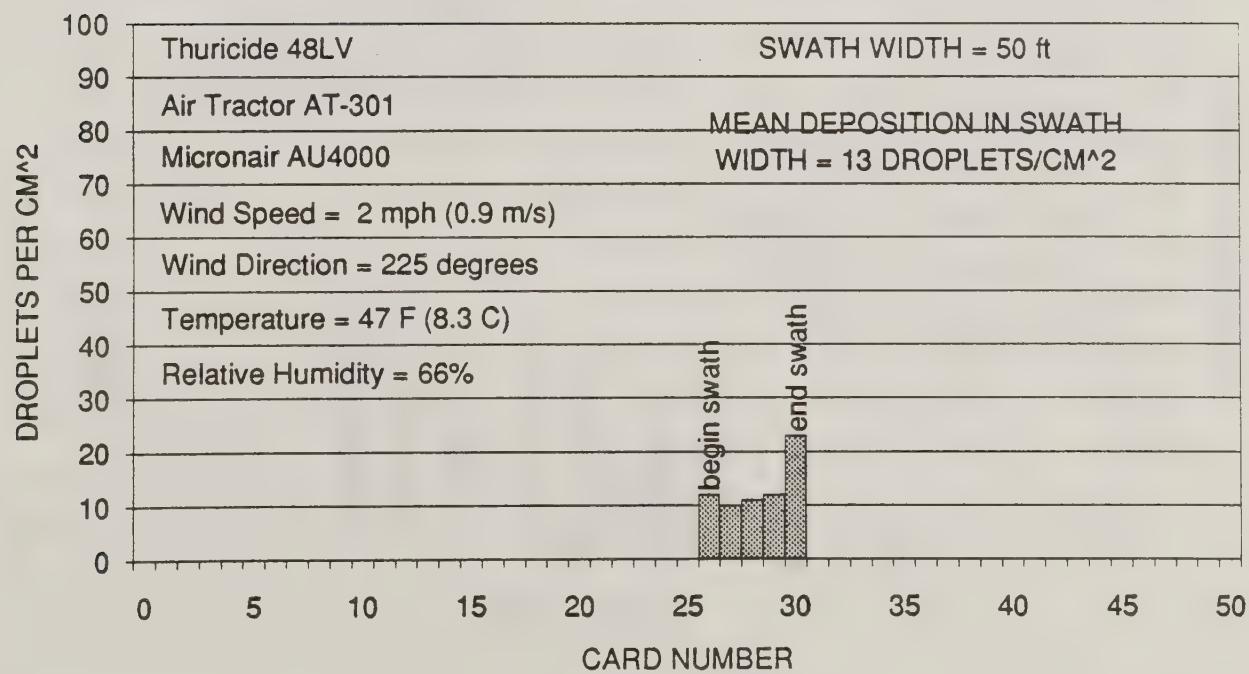
TRIAL #	CHEMICAL	AIRCRAFT	NOZZLE	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SS9	SS10	SS11	SS12	SS13	SS14	SS15	SS16	SS17	SS18	SS19	SS20	SS21	SS22	SS23	SS24
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	DIPEL 6L	AT-301	AU4000																								
2	DIPEL 6L	AT-301	AU4000																								
3	DIPEL 6L	AT-301	AU4000																								
4	DIPEL 6AF	B-205	BEECOMIST																								
5	DIPEL 6L	AT-301	AU4000																								
6	DIPEL 6L	AT-301	AU4000																								
7	DIPEL 6L	AT-301	AU4000																								
8	DIPEL 6AF	B-205	BEECOMIST																								
9	DIPEL 6AF	B-205	BEECOMIST																								
10	DIPEL 6AF	B-205	BEECOMIST																								
11	DIPEL 6AF	AT-301	AU4000																								
12	DIPEL 6AF	AT-301	AU4000																								
13	DIPEL 6AF	AT-301	AU4000																								
14	DIPEL 6AF	AT-301	AU4000																								
15	DIPEL 6AF	AT-301	AU4000																								
16	DIPEL 6AF	AT-301	AU4000																								
17	THUR 48L	V	B-205	BEECOMIST																							
18	THUR 48L	V	B-205	BEECOMIST																							
19	THUR 48L	V	B-205	BEECOMIST																							
20	THUR 48L	V	B-205	BEECOMIST																							
21	THUR 48L	V	B-201	BEECOMIST																							
22	THUR 48L	V	AT-301	AU4000																							
23	THUR 48L	V	AT-301	AU4000																							
24	THUR 48L	V	AT-301	AU4000																							
25	THUR 32L	V	B-205	BEECOMIST																							
26	THUR 32L	V	B-205	BEECOMIST																							
27	THUR 32L	V	AT-301	AU4000																							
28	THUR 32L	V	AT-301	AU4000																							
29	THUR 32L	V	AT-301	AU4000																							
30	THUR 32L	V	AT-301	AU4000																							
31	THUR 32L	V	AT-301	AU4000																							
32	THUR 32L	V	AT-301	AU4000																							
33	THUR 32L	V	AT-301	AU4000																							
34	DIPEL 6AF	AT-301	AU4000																								
35	DIPEL 6AF	AT-301	AU4000																								
36	DIPEL 6AF	AT-301	AU4000																								
37	DIPEL 6AF	AT-301	AU4000																								
38	DIPEL 6L	B-205	BEECOMIST																								
39	DIPEL 6L	B-205	BEECOMIST																								
40	DIPEL 6L	B-205	BEECOMIST																								
41	no	trial	#41																								
42	DIPEL 6L	B-205	AU5000																								
43	DIPEL 6L	B-205	AU5000																								
44	DIPEL 6L	B-205	AU5000																								
45	DIPEL 6L	B-205	AU5000																								

no stake cards

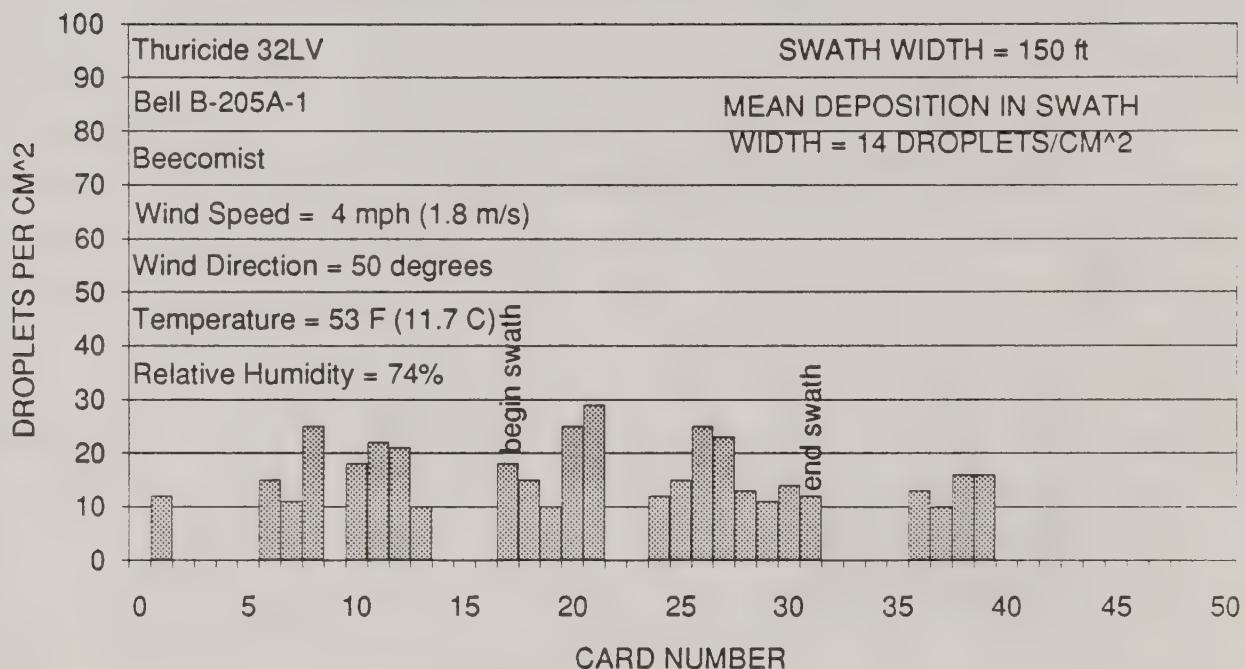
TRIAL 3 - STAKE SOUTH SIDE



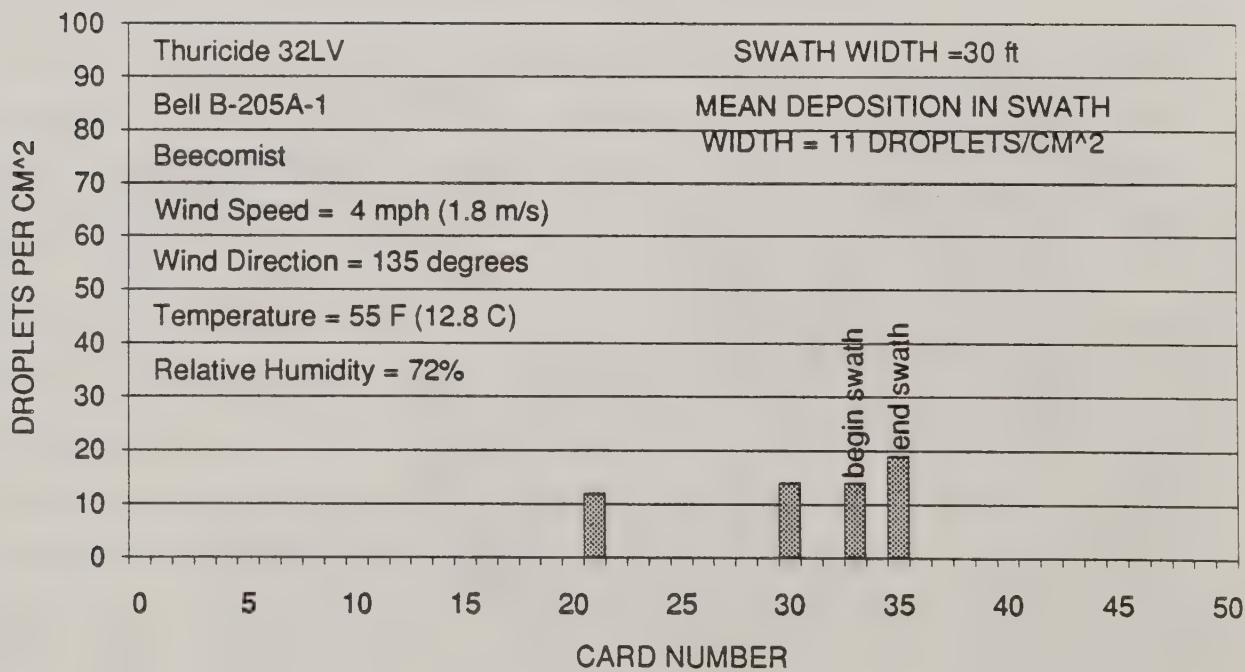
TRIAL 23 - STAKE SOUTH SIDE



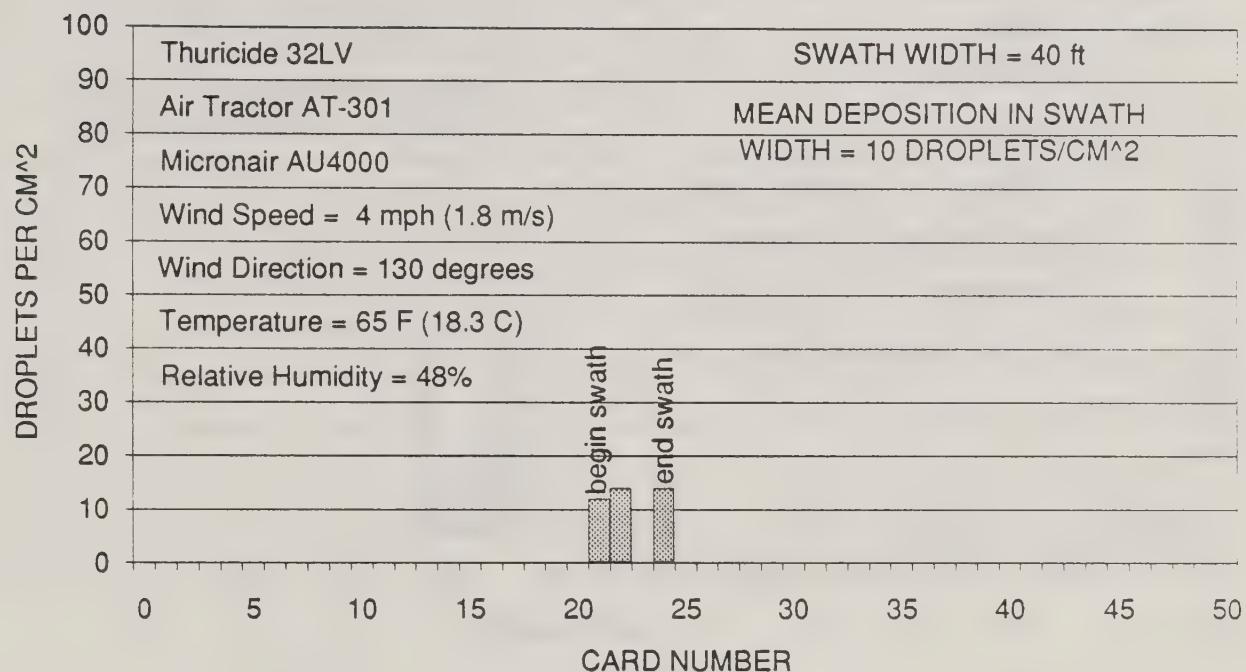
TRIAL 25 - STAKE SOUTH SIDE



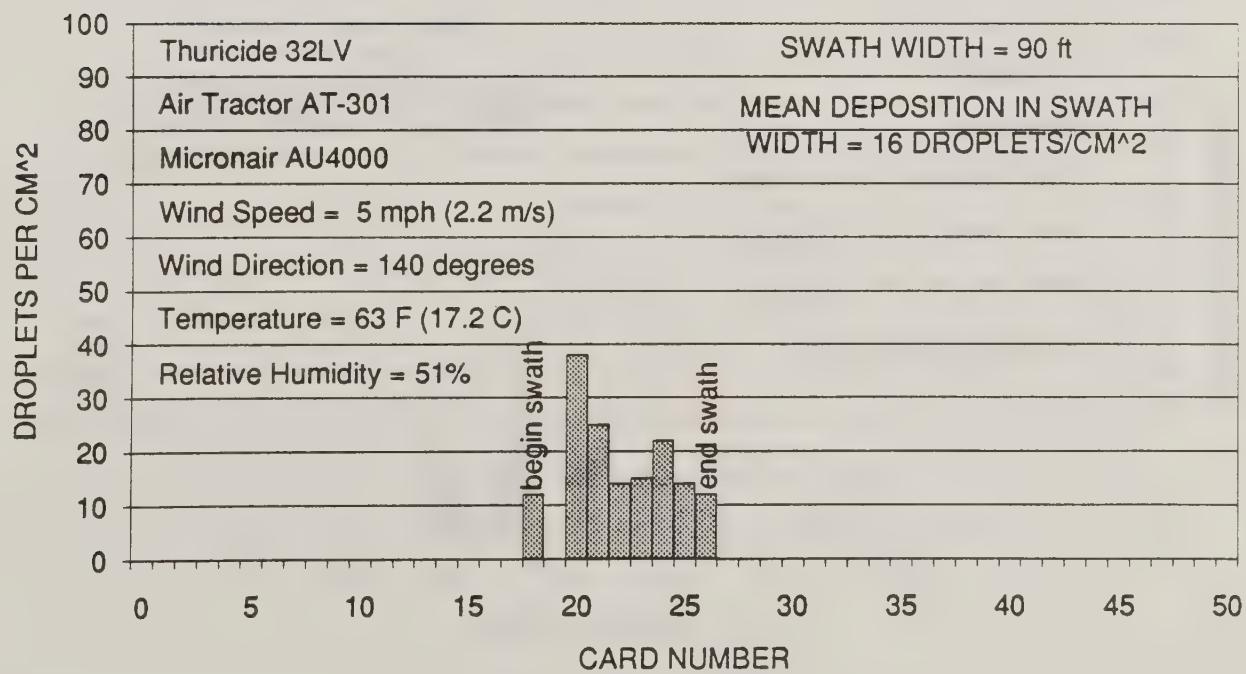
TRIAL 26 - STAKE SOUTH SIDE



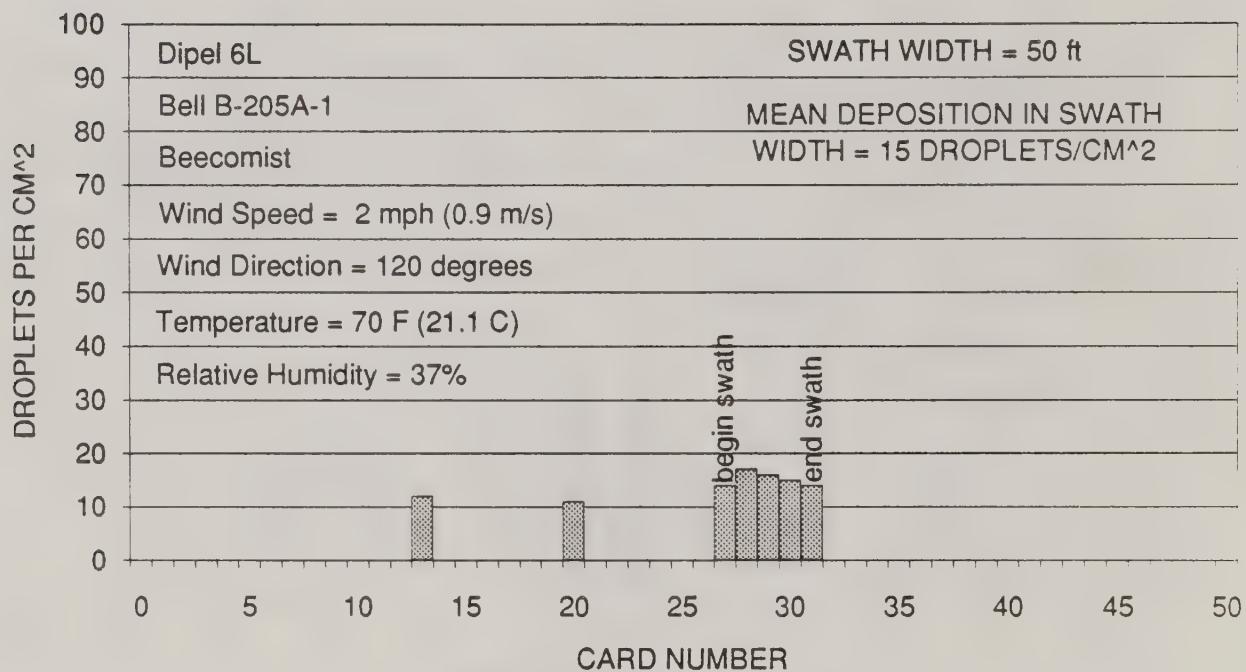
TRIAL 29 - STAKE SOUTH SIDE



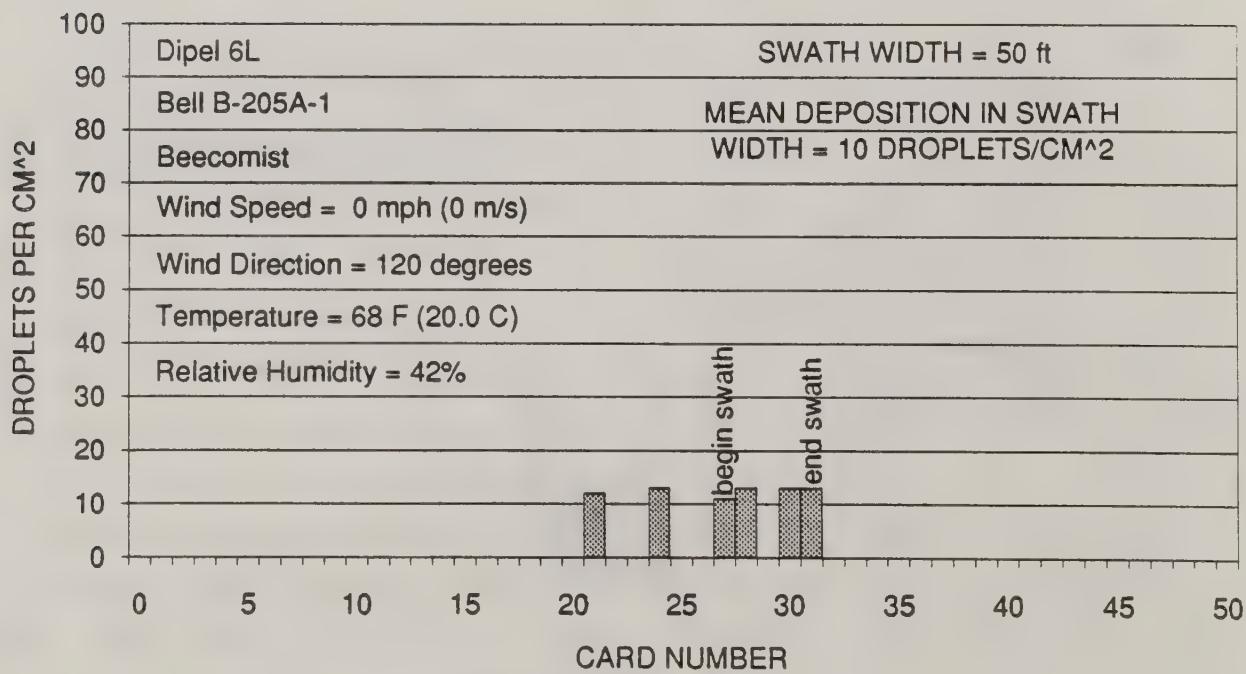
TRIAL 30 - STAKE SOUTH SIDE



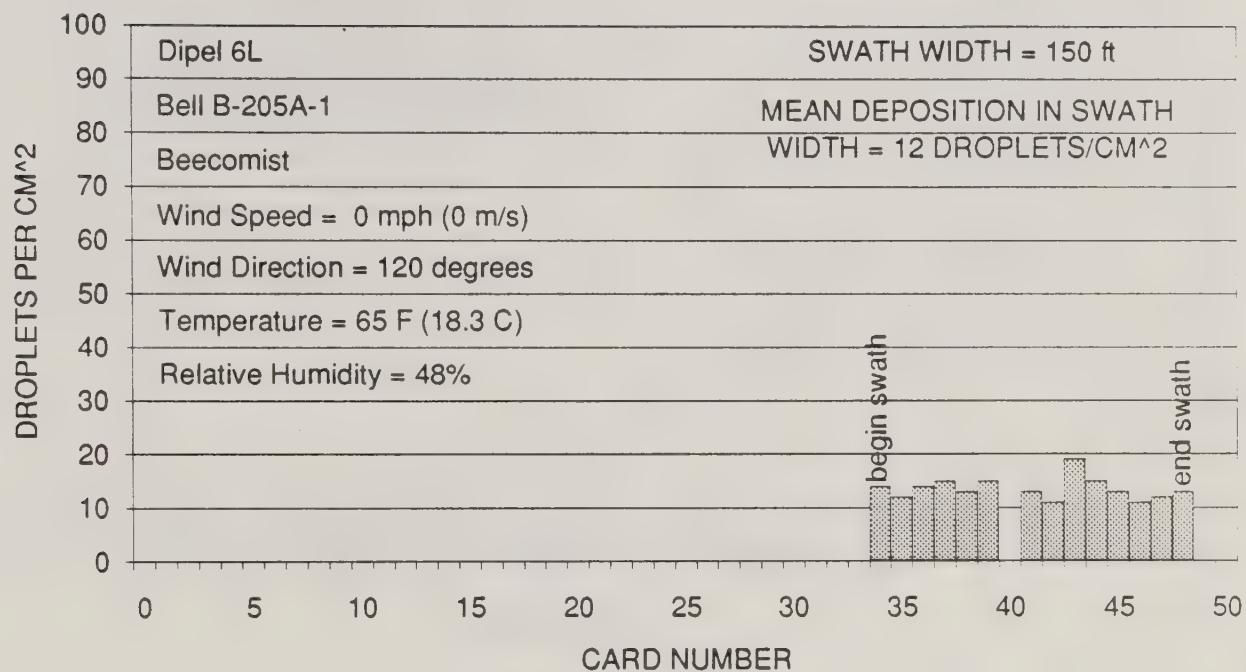
TRIAL 38 - STAKE SOUTH SIDE



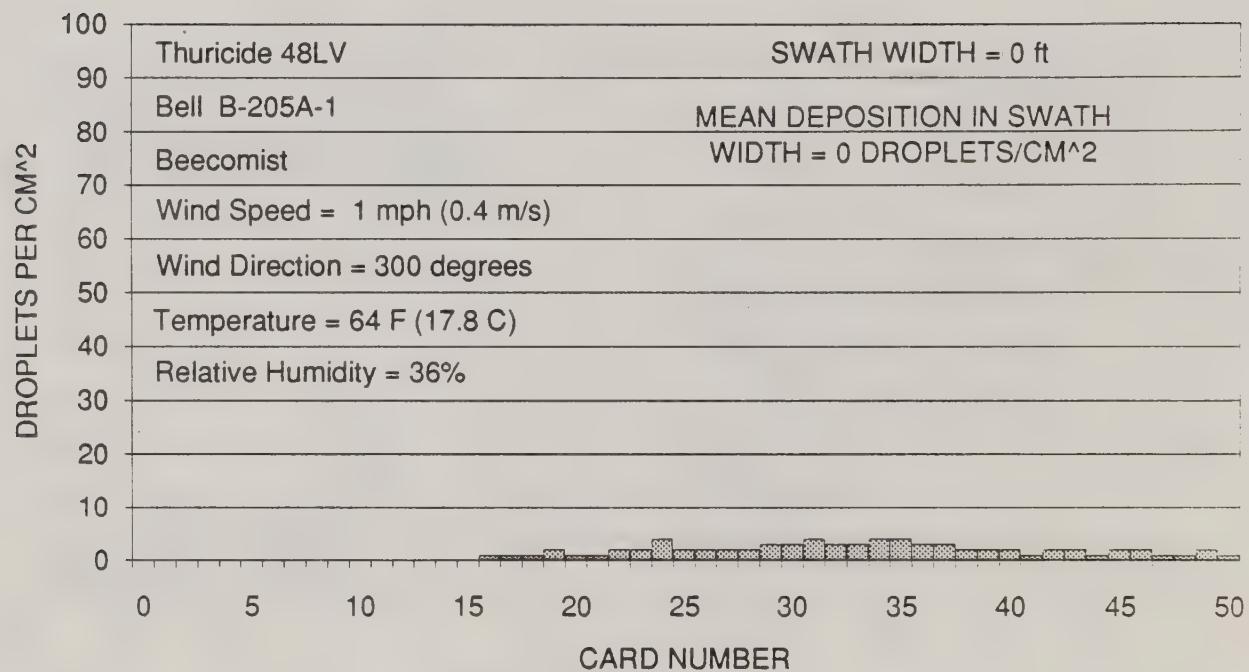
TRIAL 39 - STAKE SOUTH SIDE



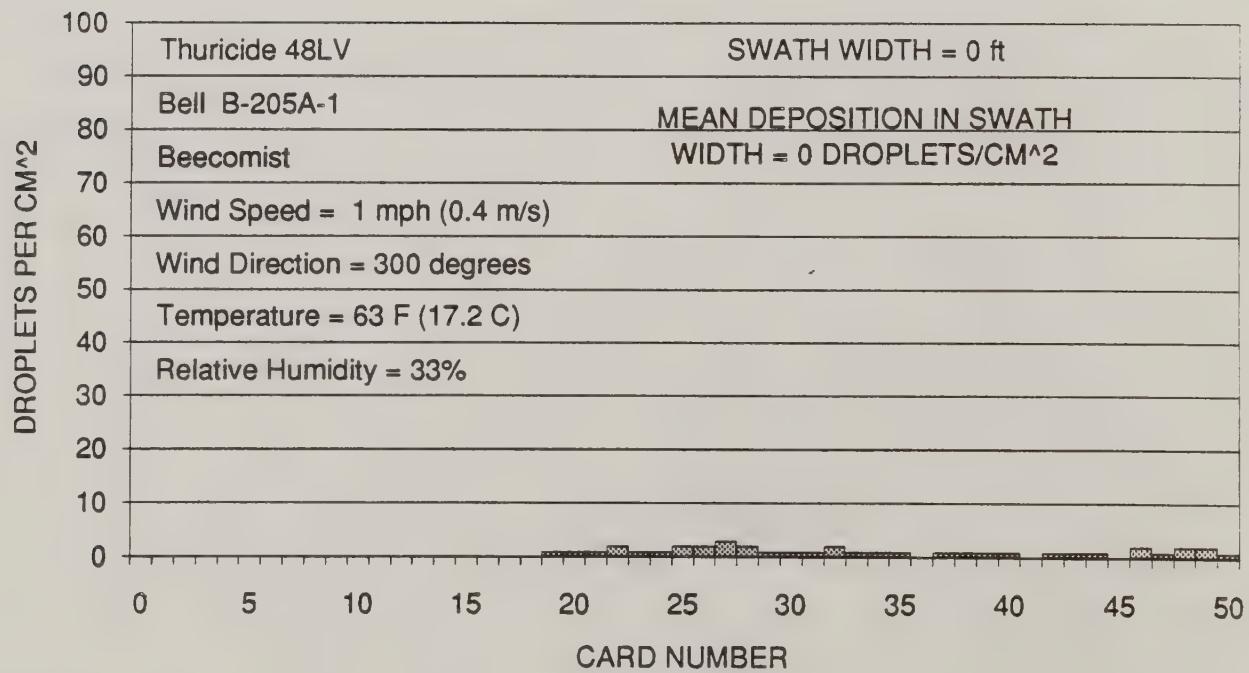
TRIAL 40 - STAKE SOUTH SIDE



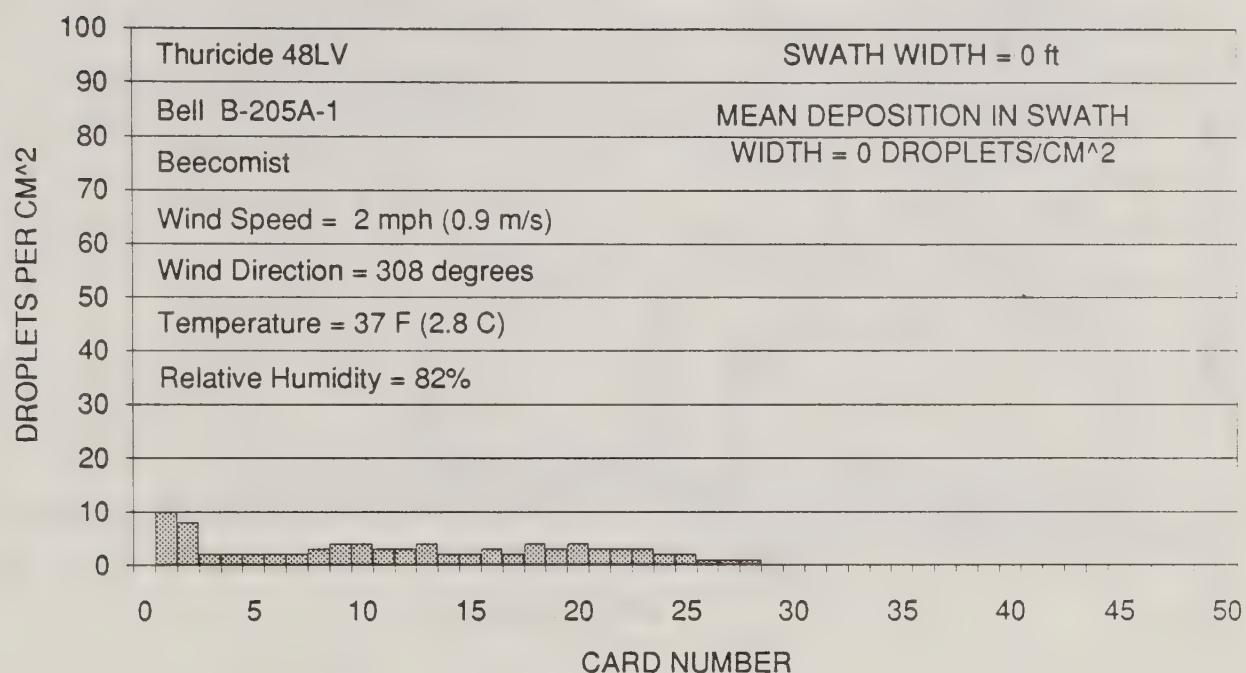
TRIAL 17 - GROUND CARD



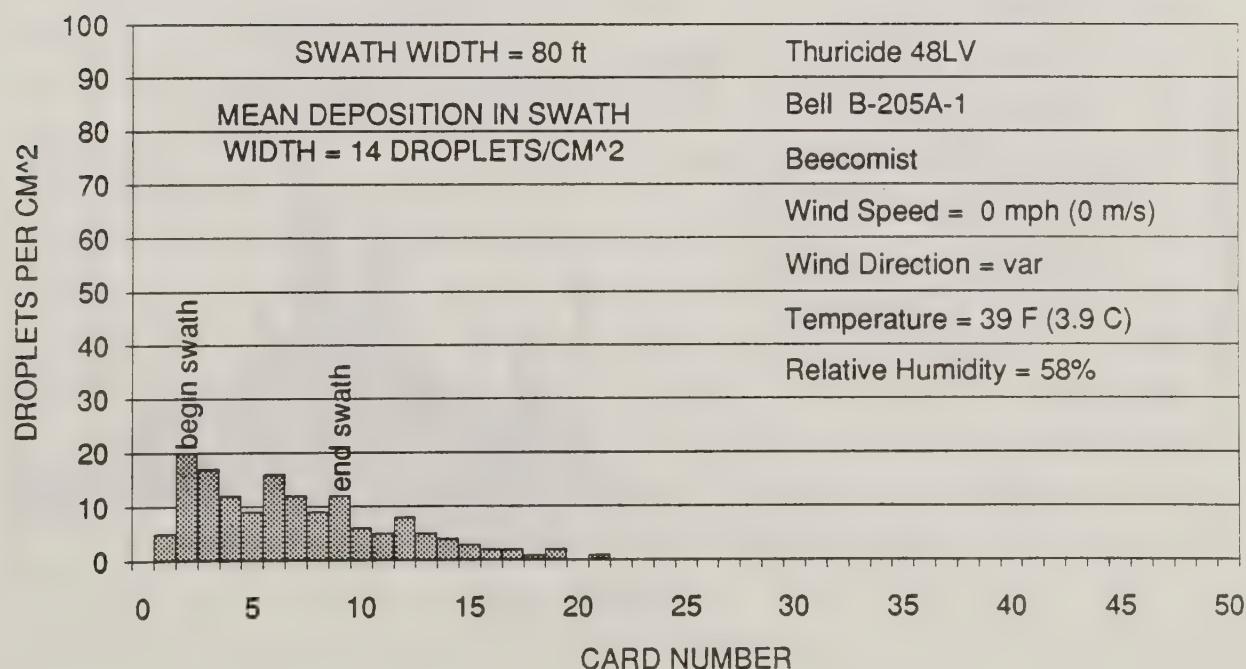
TRIAL 18 - GROUND CARD



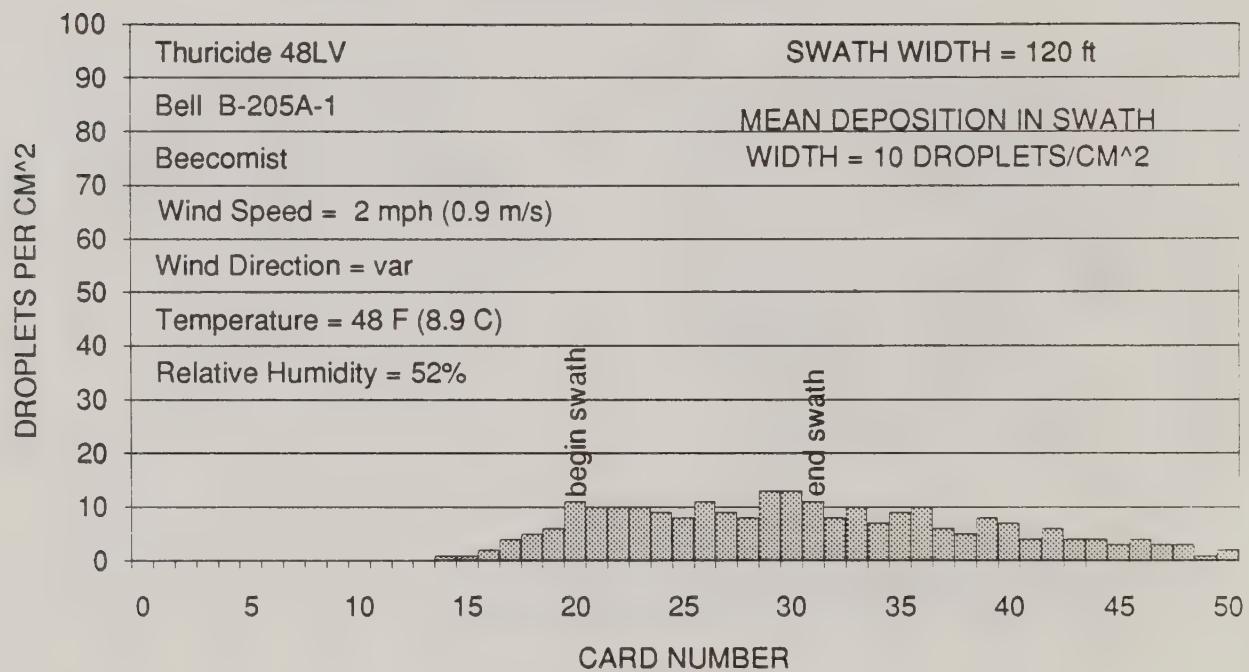
TRIAL 19 - GROUND CARD



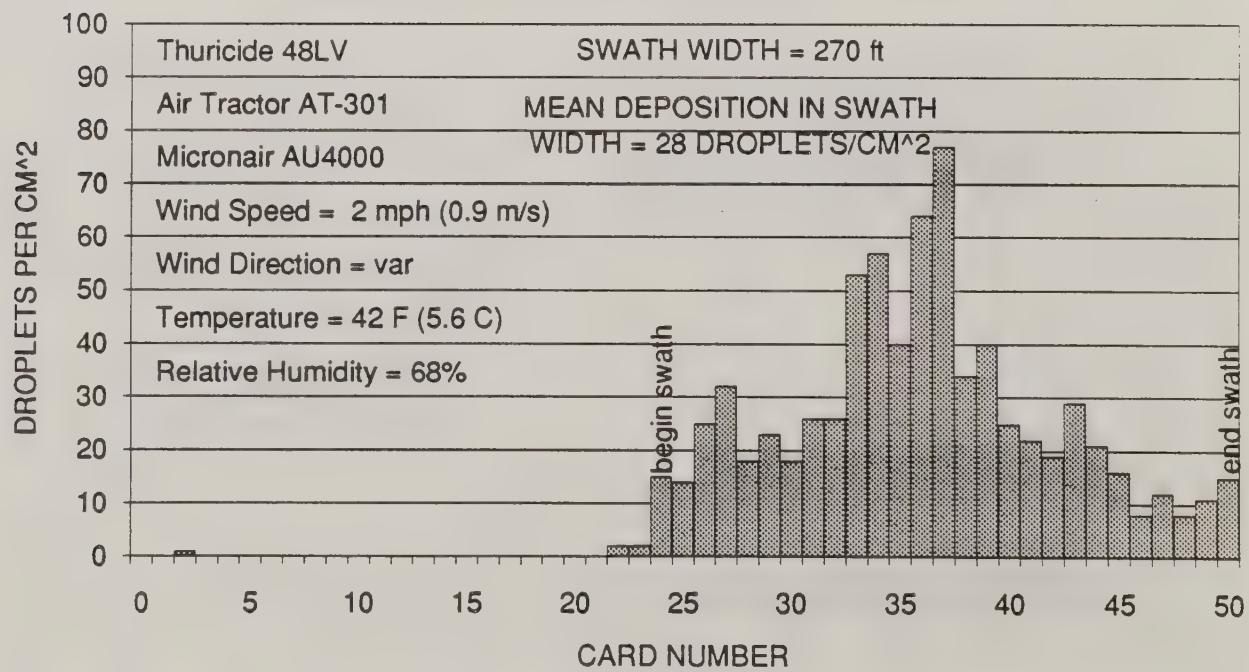
TRIAL 20 - GROUND CARD



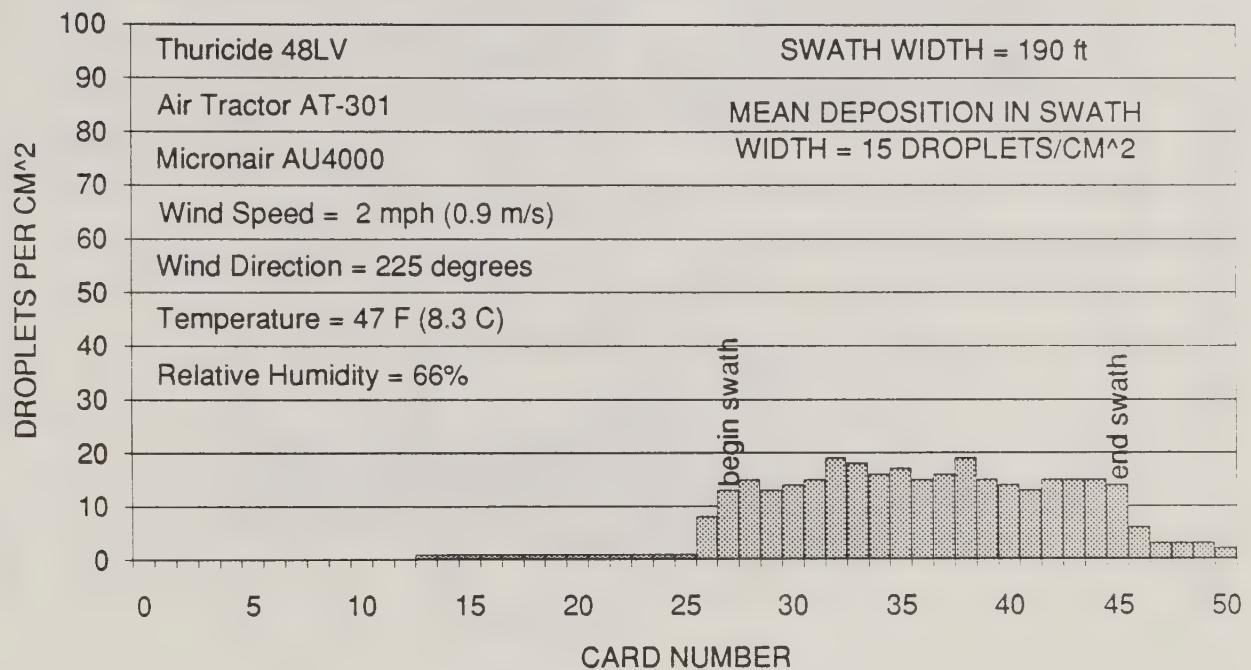
TRIAL 21 - GROUND CARD



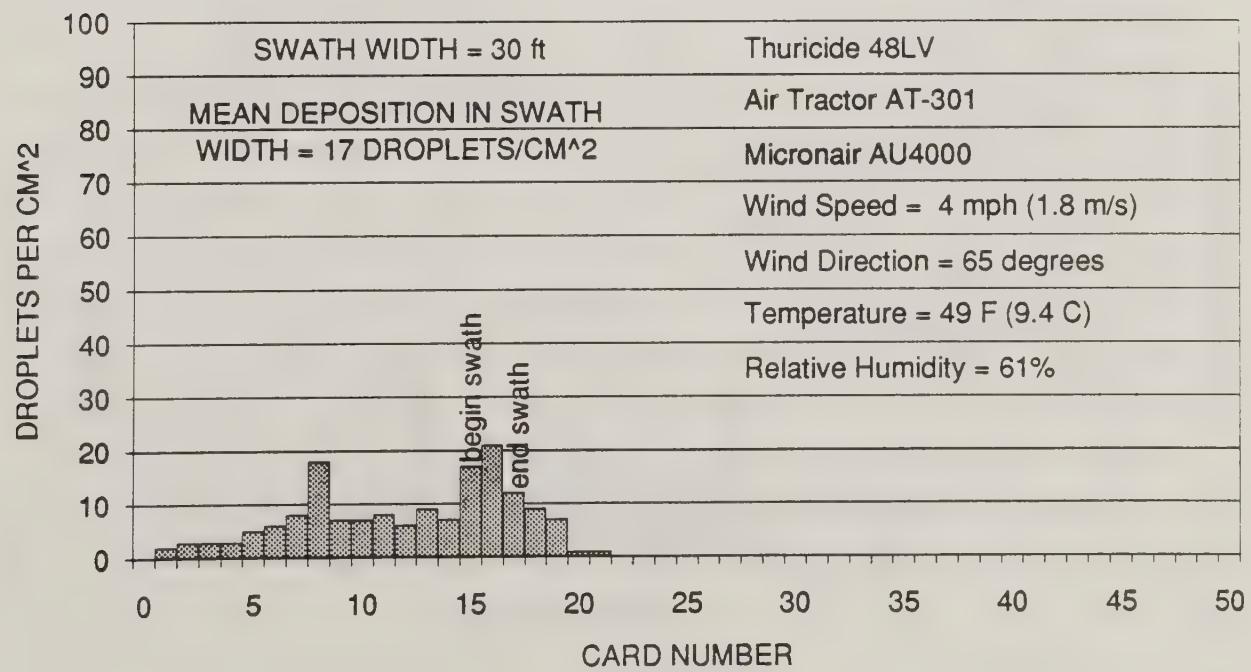
TRIAL 22 - GROUND CARD



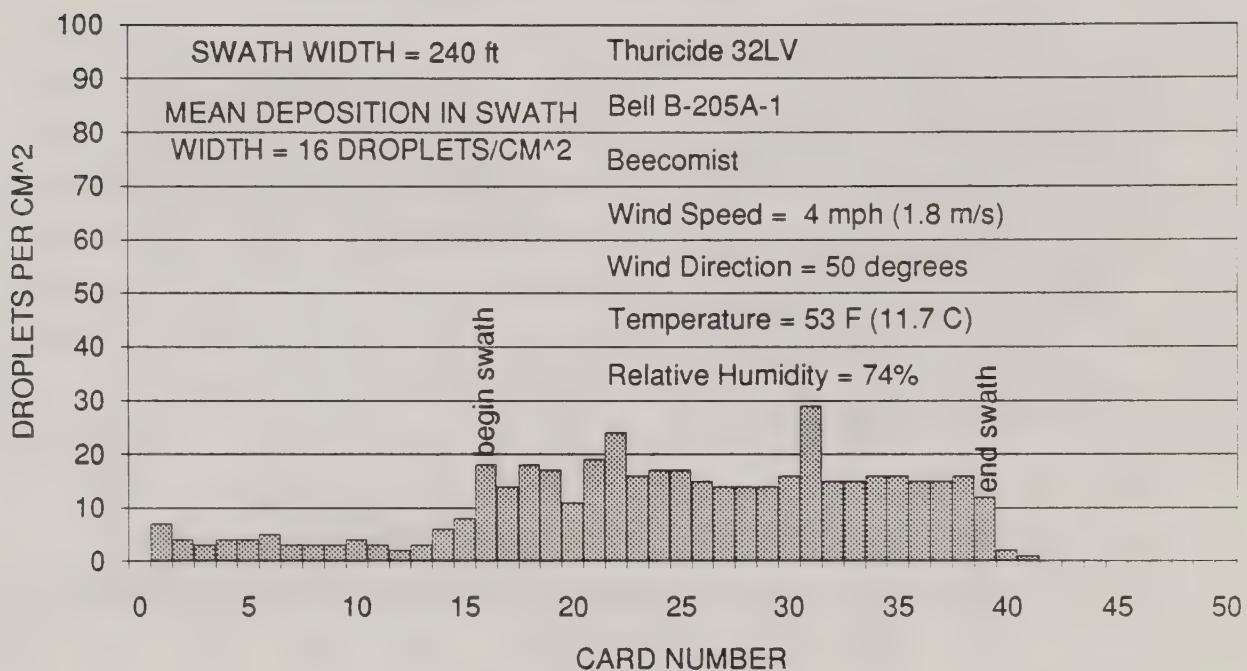
TRIAL 23 - GROUND CARD



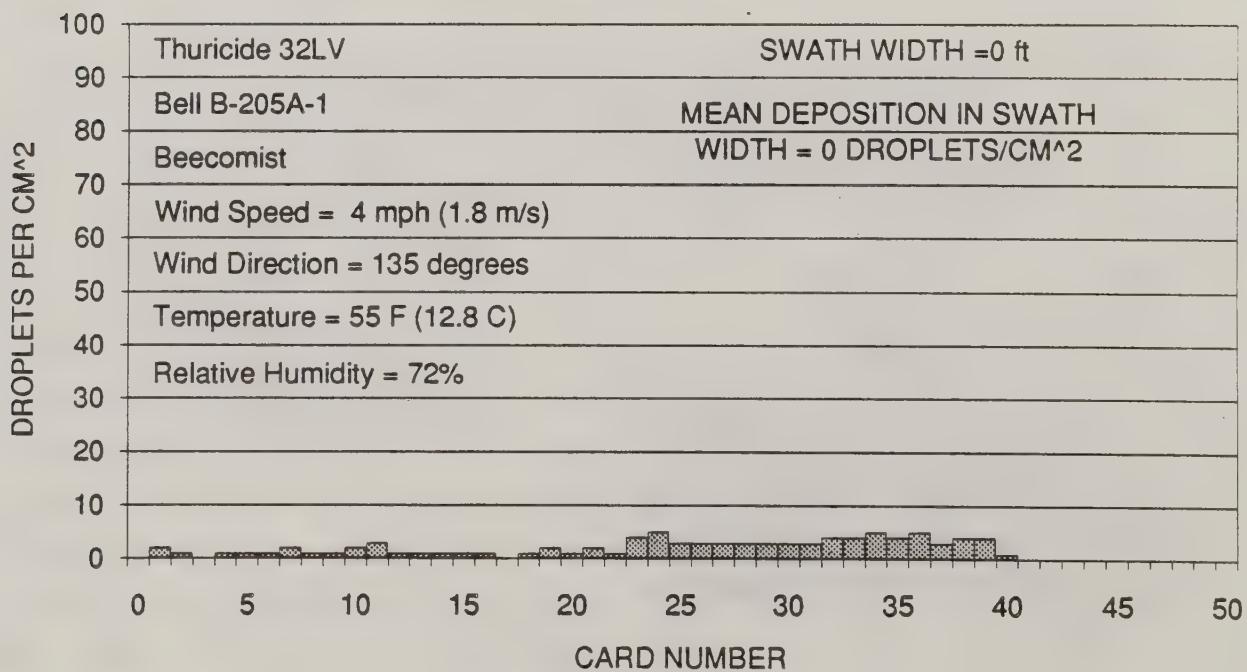
TRIAL 24 - GROUND CARD



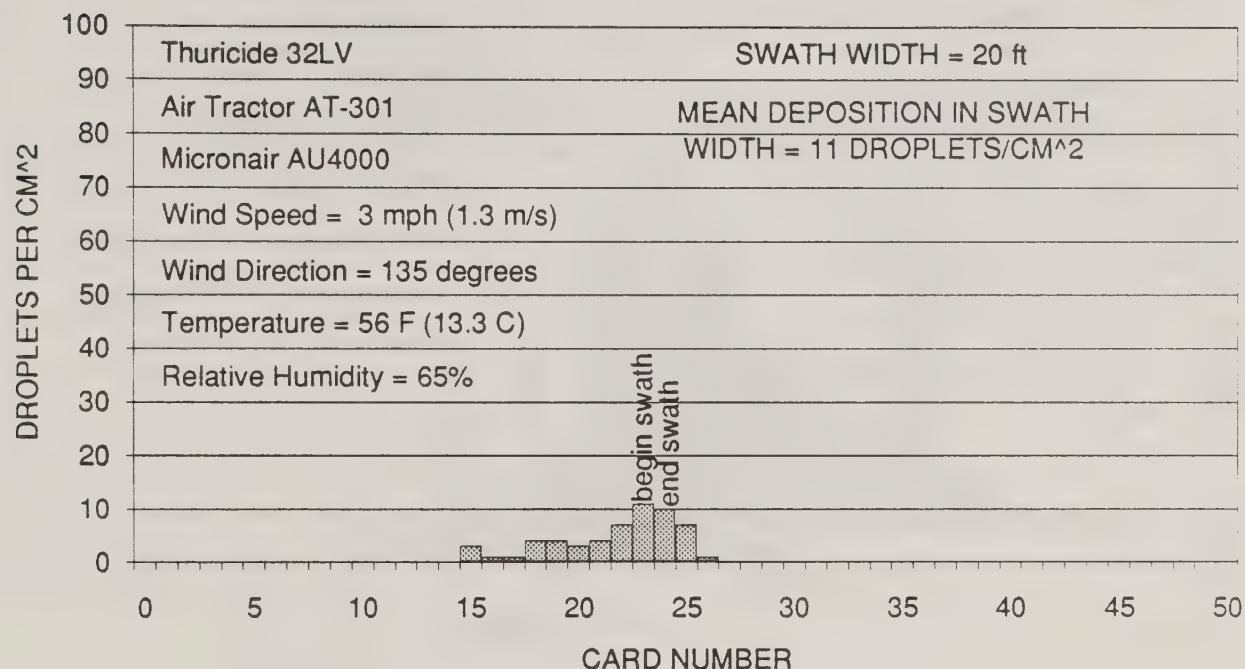
TRIAL 25 - GROUND CARD



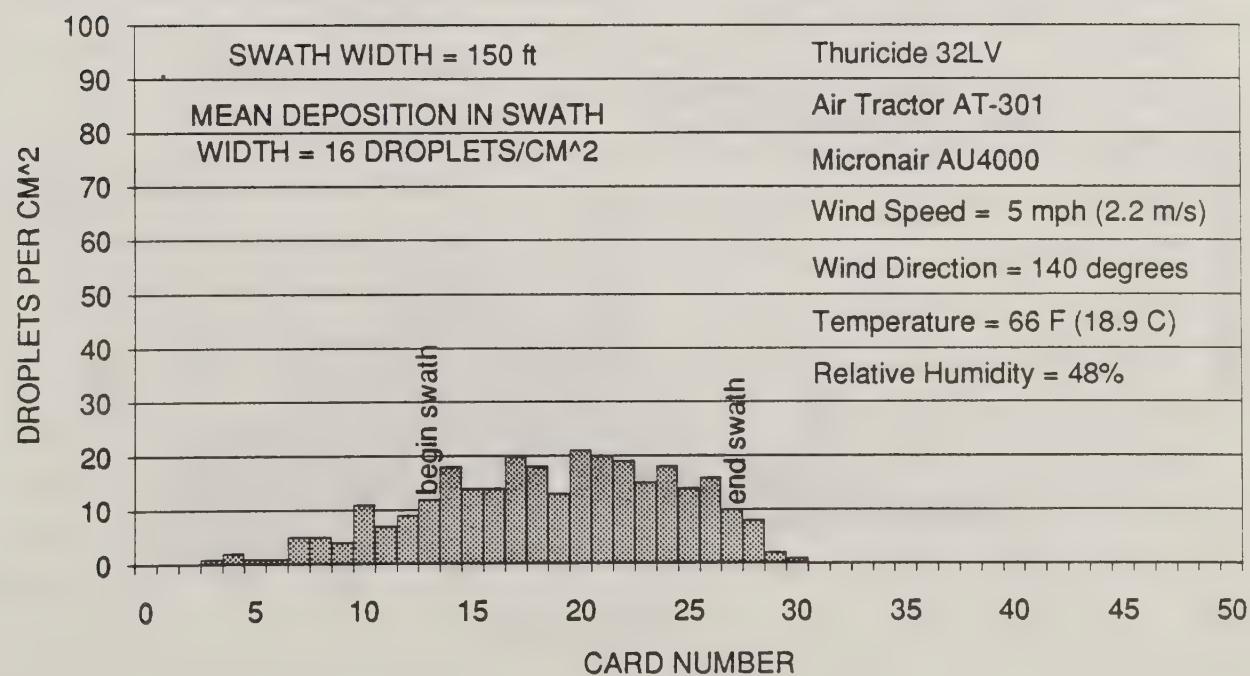
TRIAL 26 - GROUND CARD



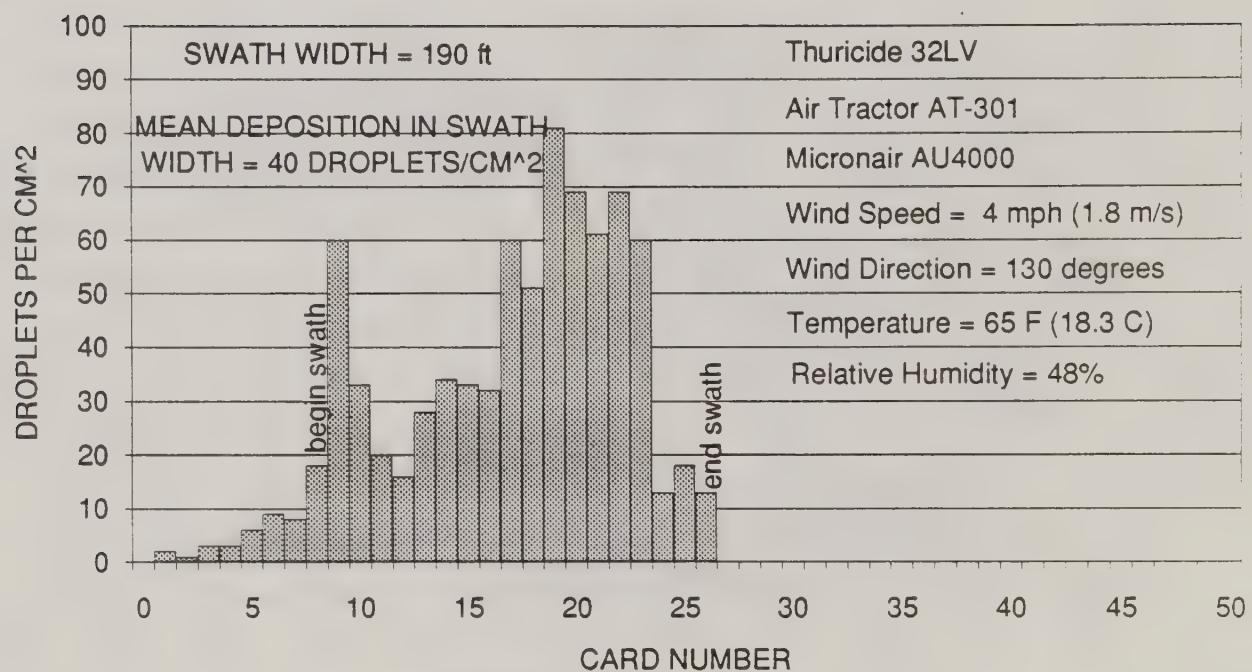
TRIAL 27 - GROUND CARD



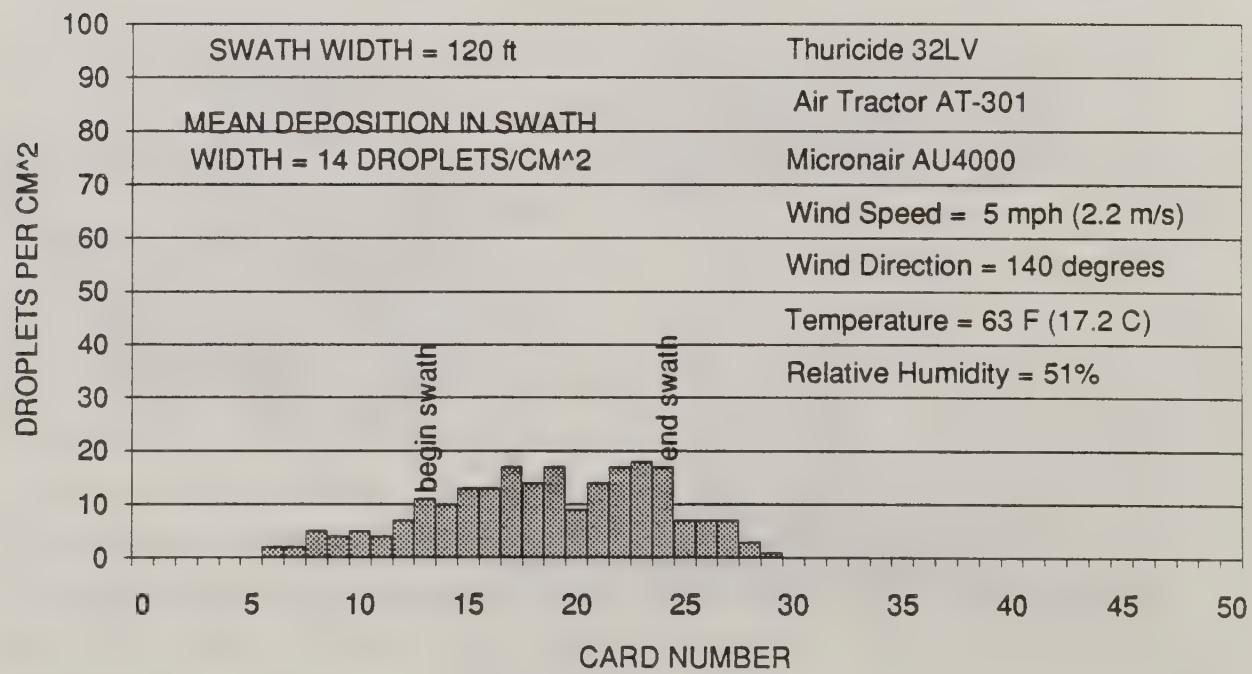
TRIAL 28 - GROUND CARD



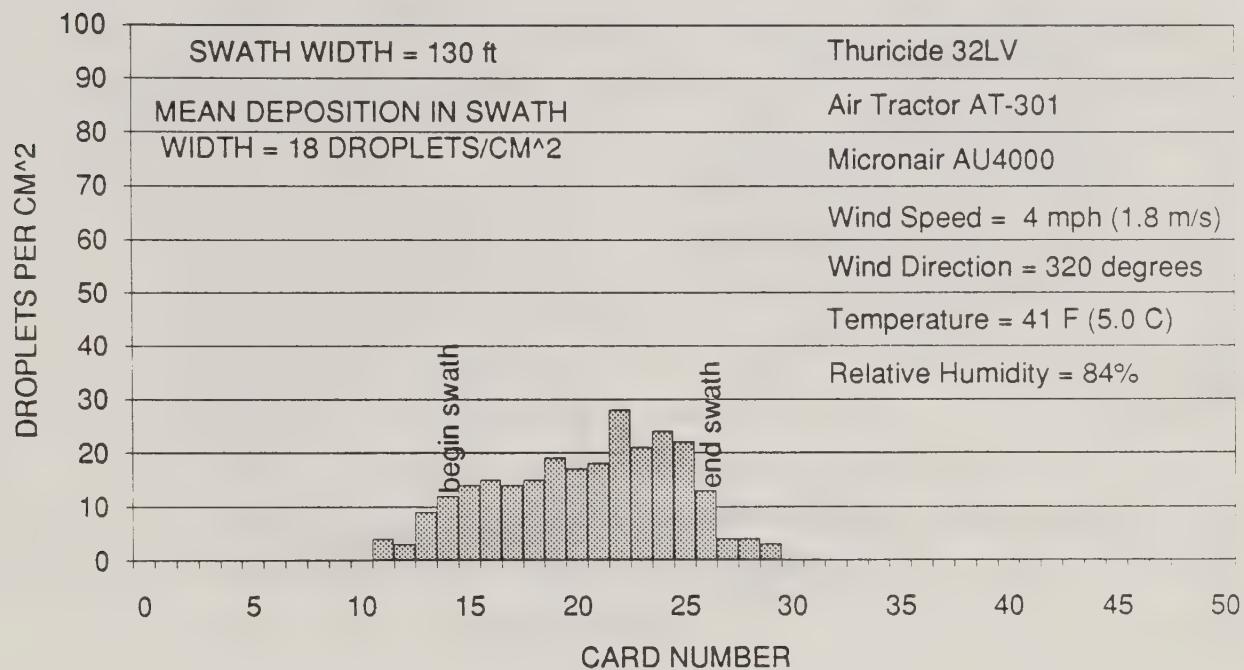
TRIAL 29 - GROUND CARD



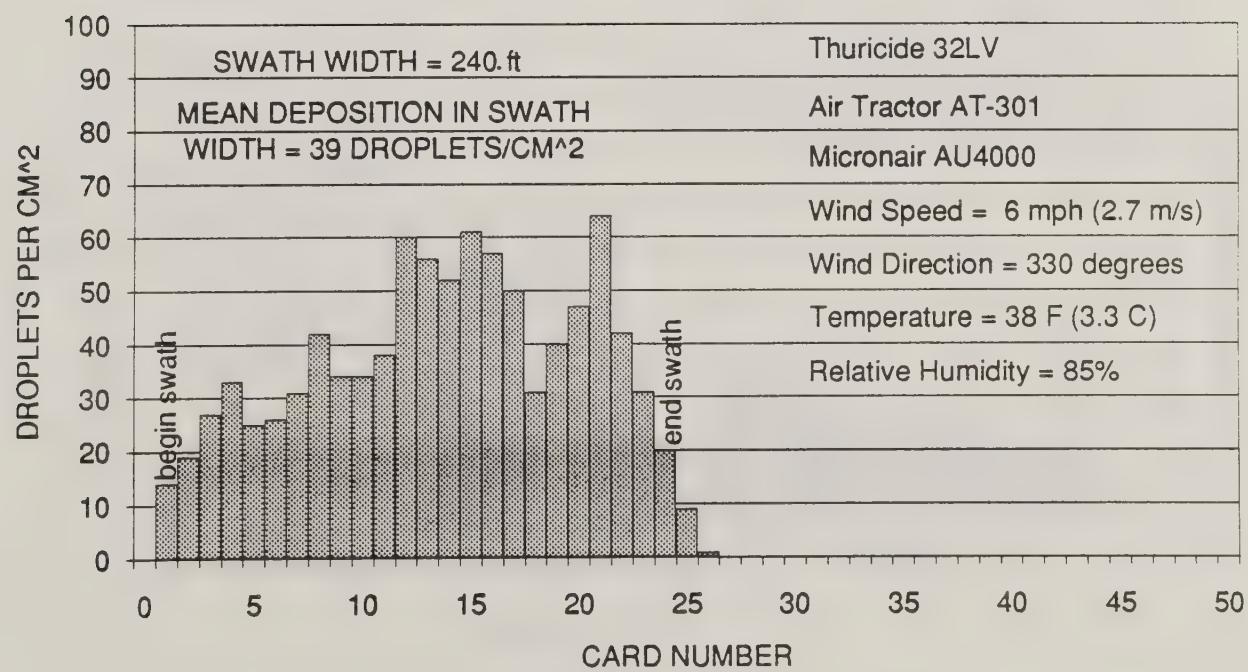
TRIAL 30 - GROUND CARD



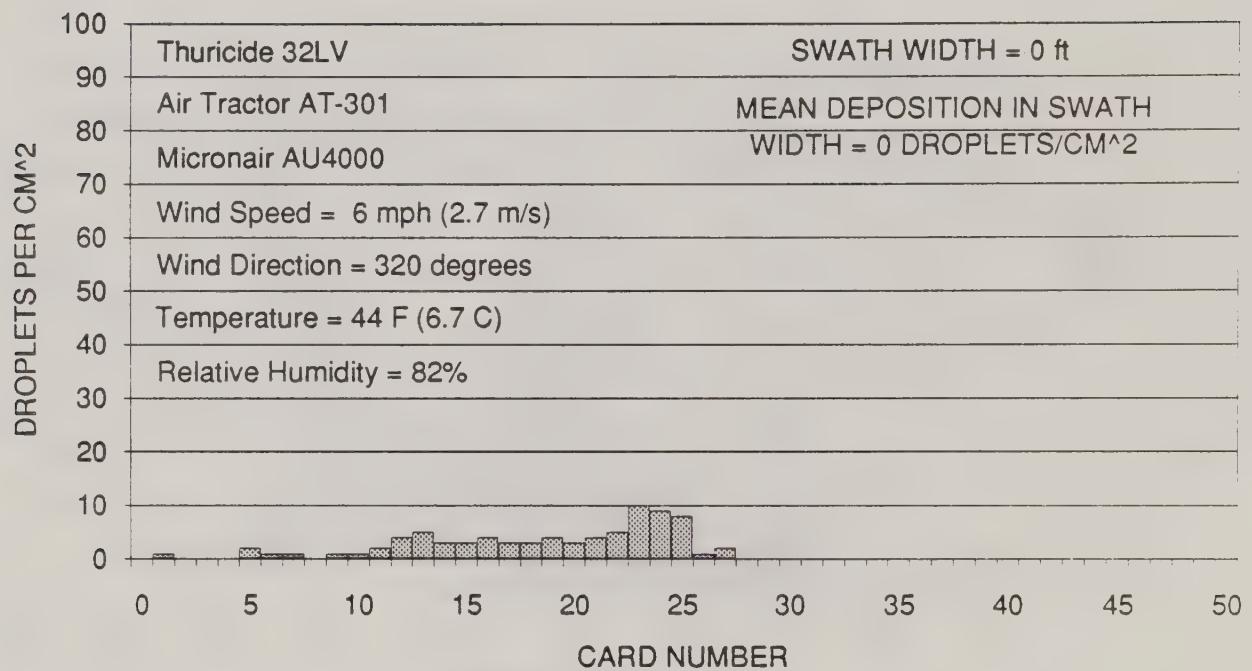
TRIAL 31 - GROUND CARD



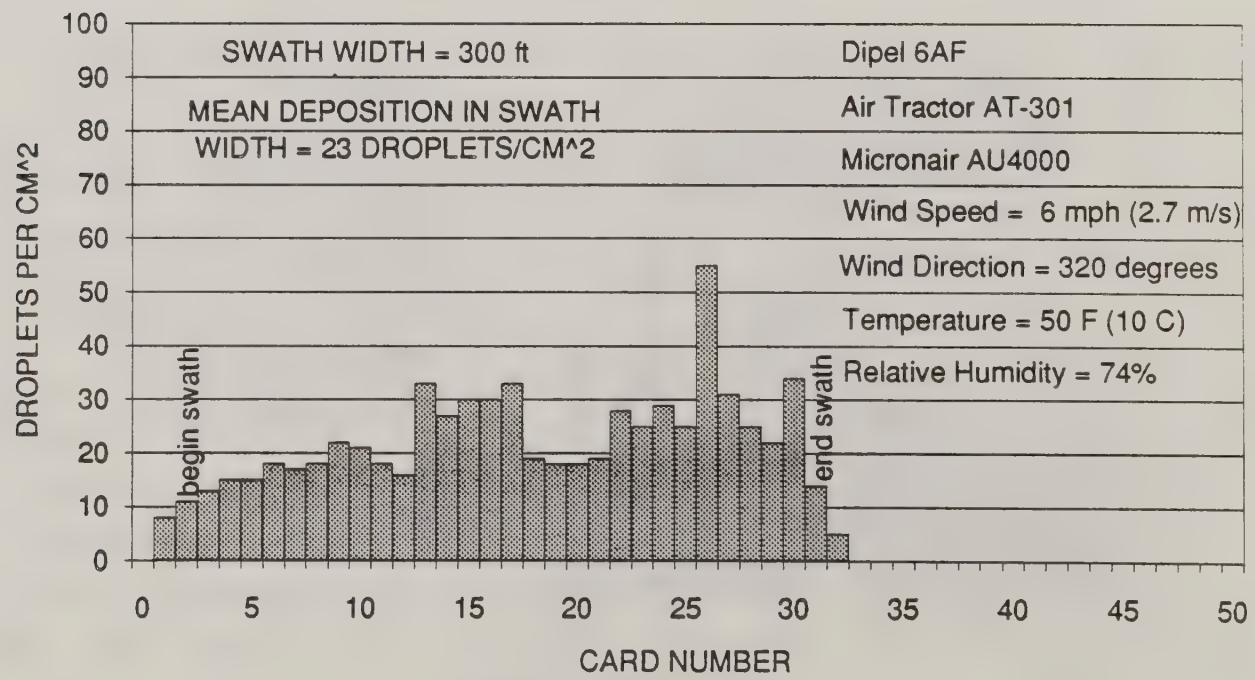
TRIAL 32 - GROUND CARD



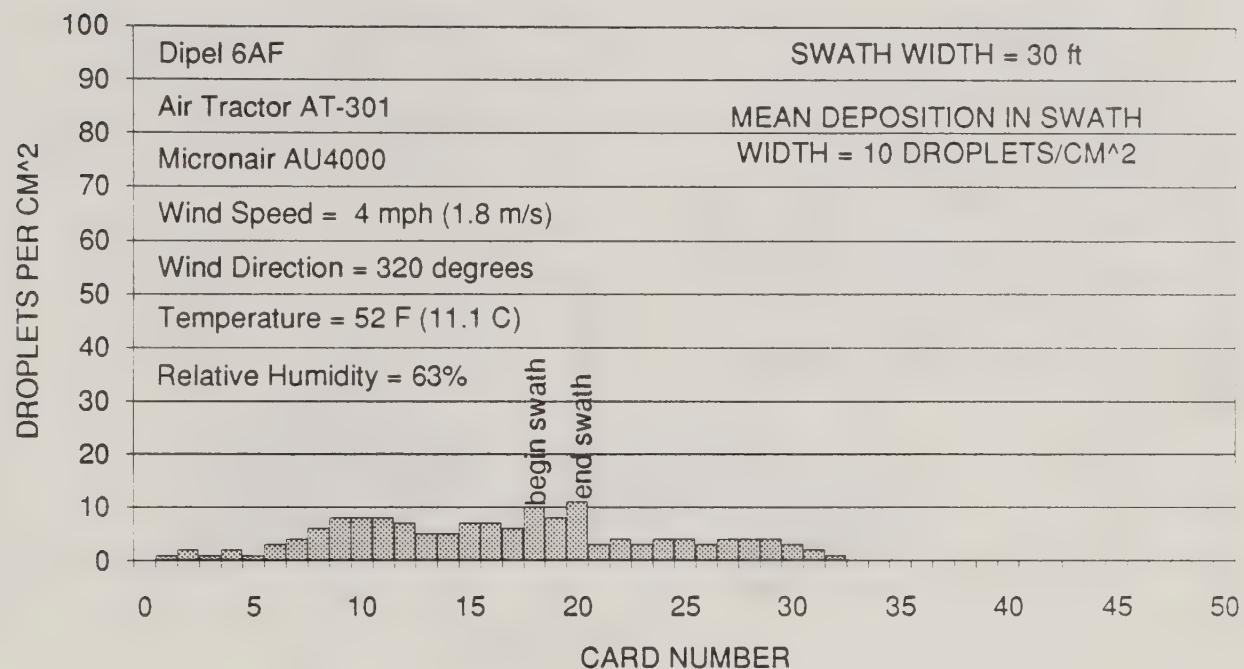
TRIAL 33 - GROUND CARD



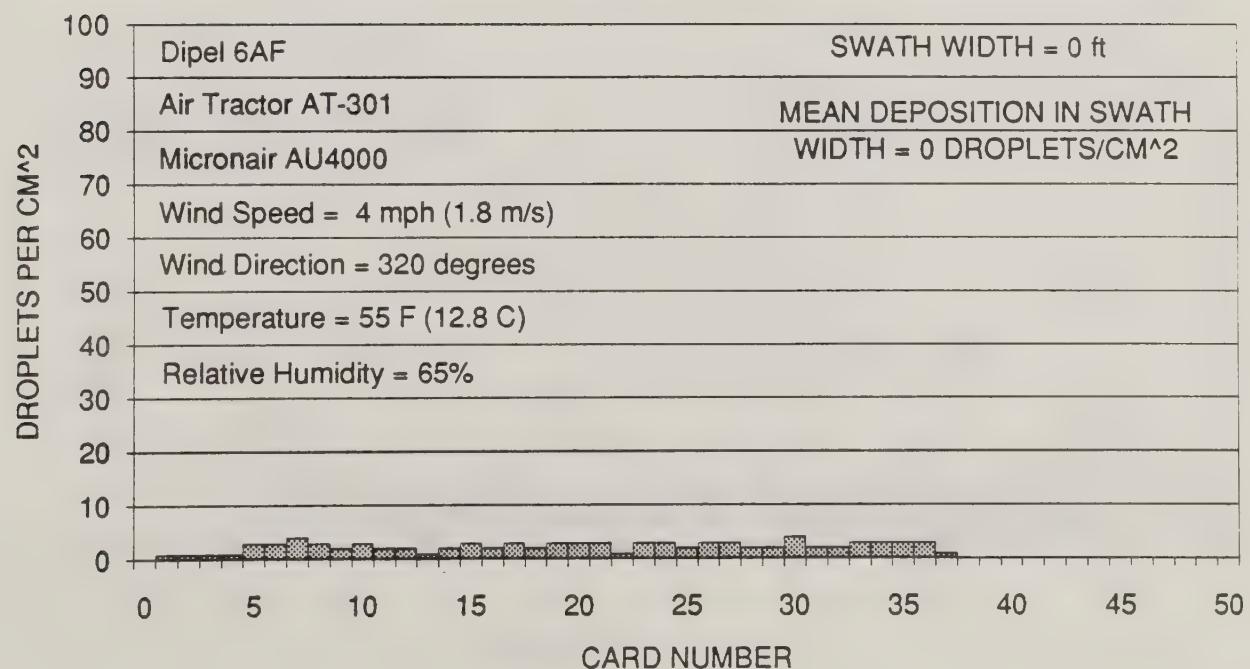
TRIAL 34 - GROUND CARD



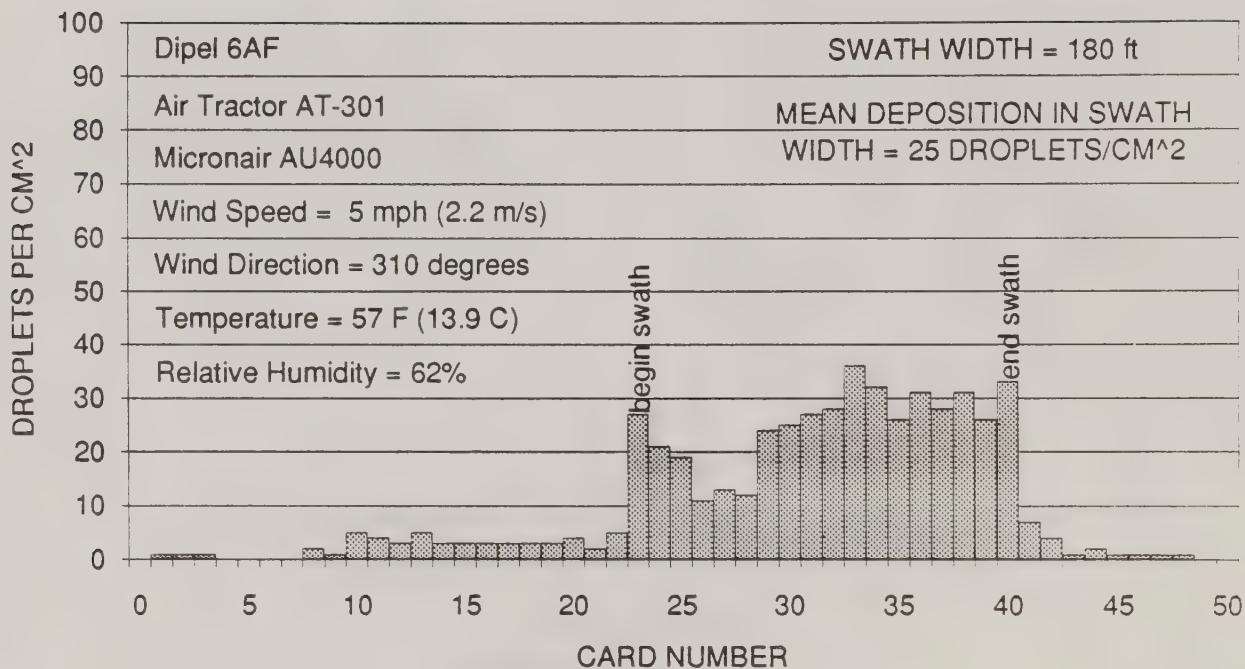
TRIAL 35 - GROUND CARD



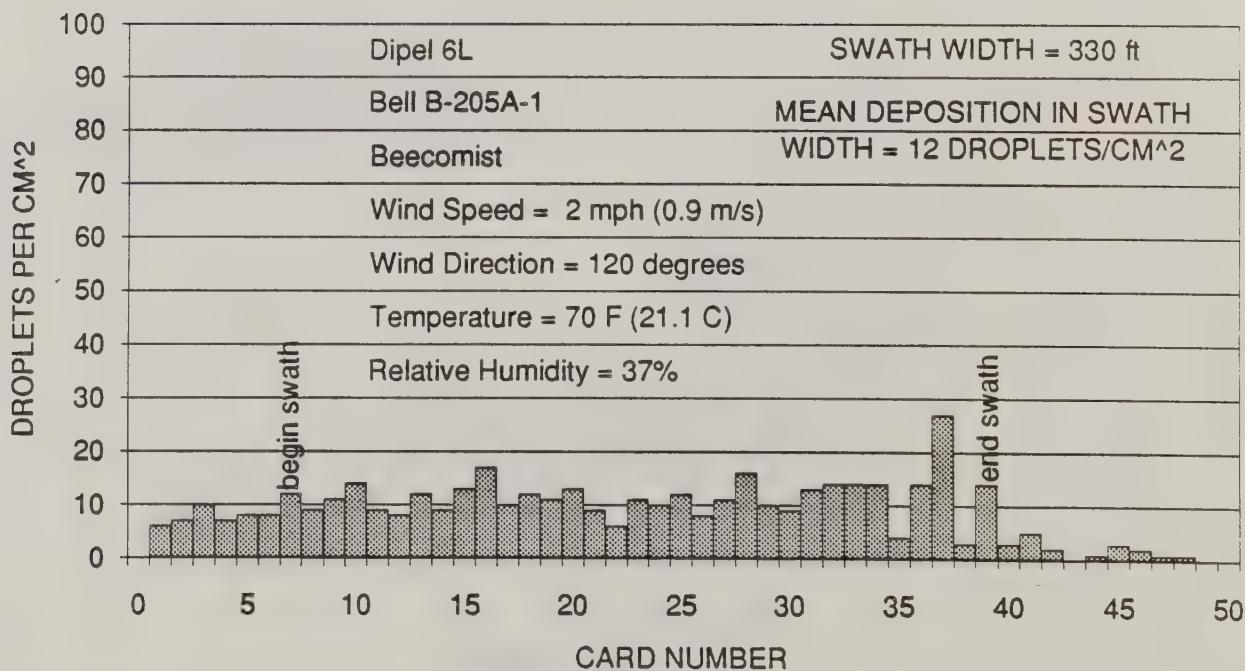
TRIAL 36 - GROUND CARD



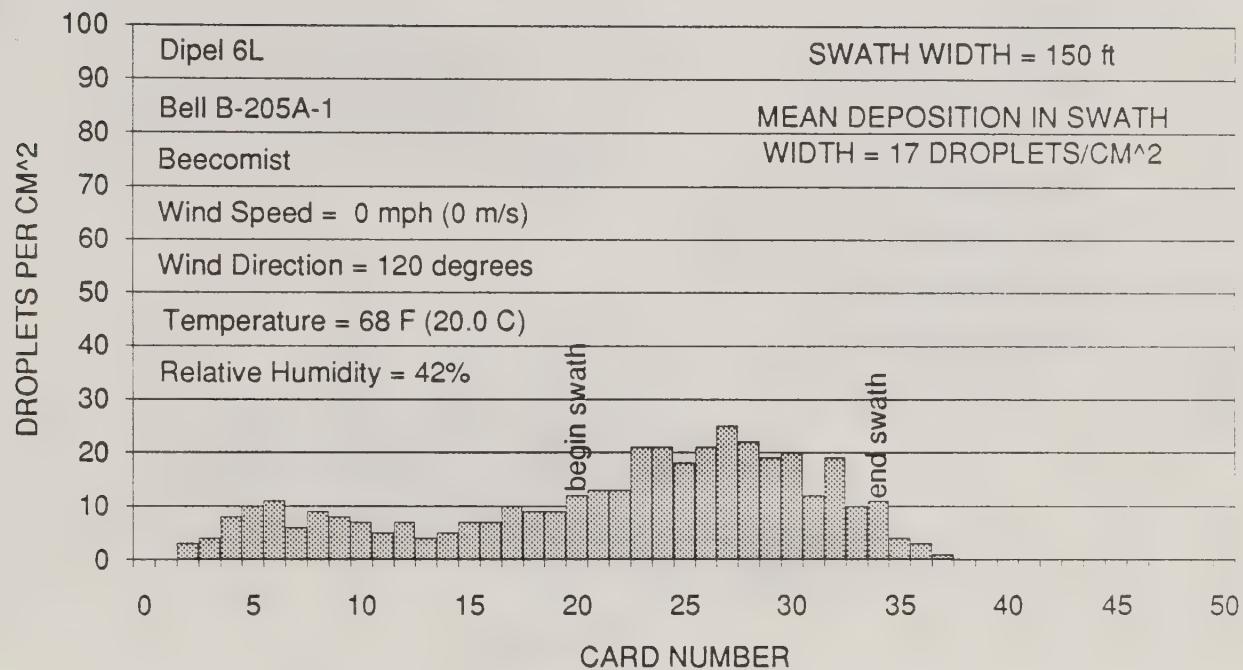
TRIAL 37 - GROUND CARD



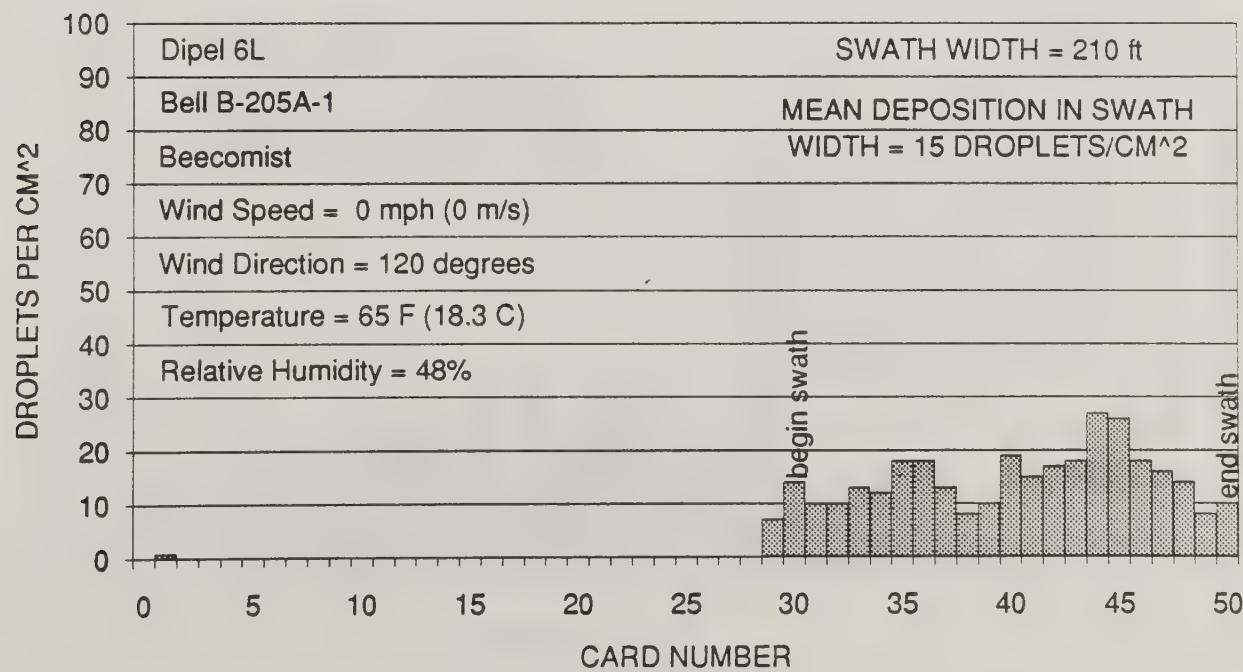
TRIAL 38 - GROUND CARD



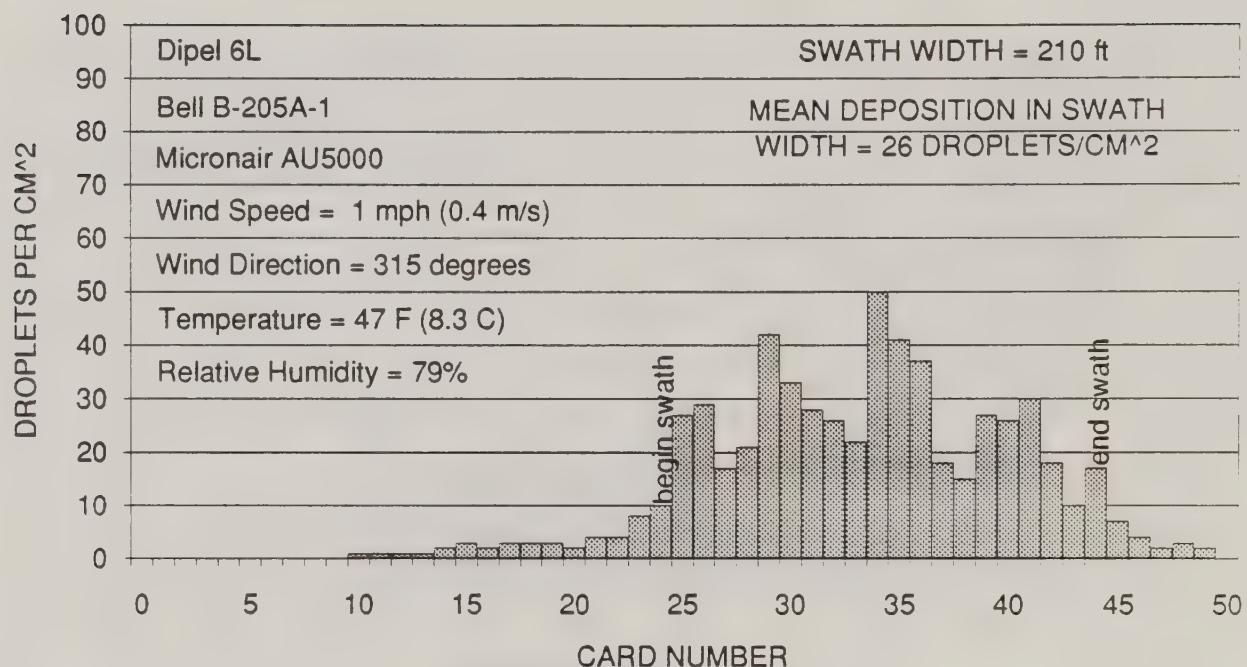
TRIAL 39 - GROUND CARD



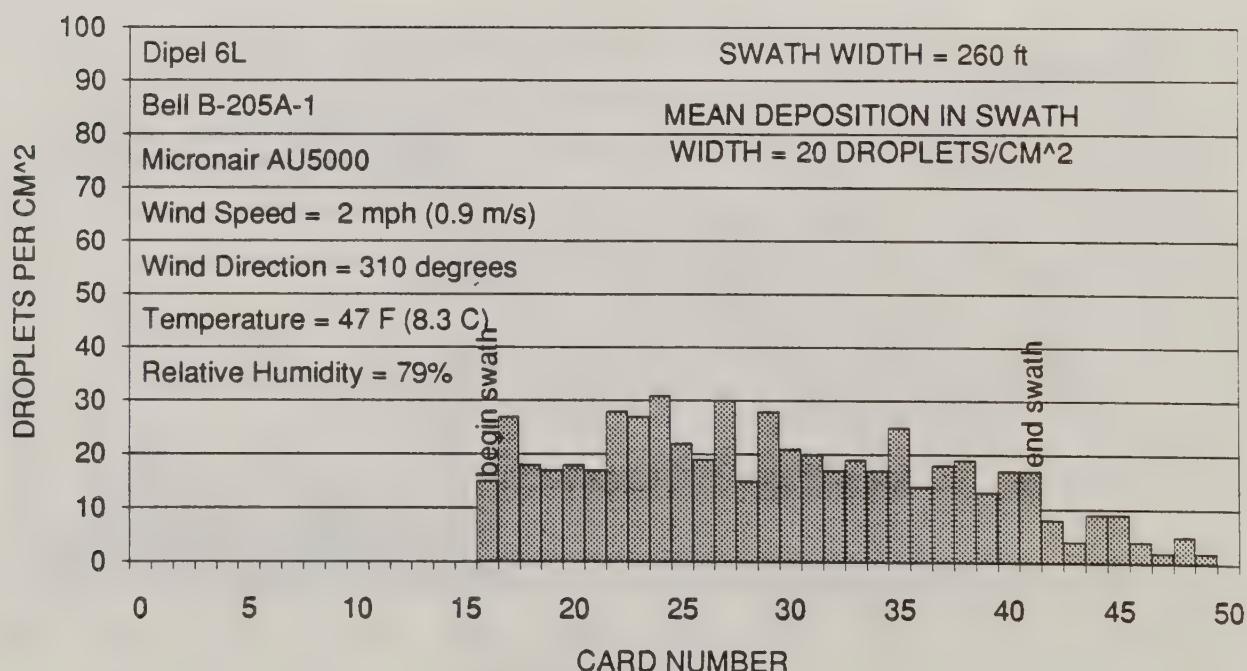
TRIAL 40 - GROUND CARD



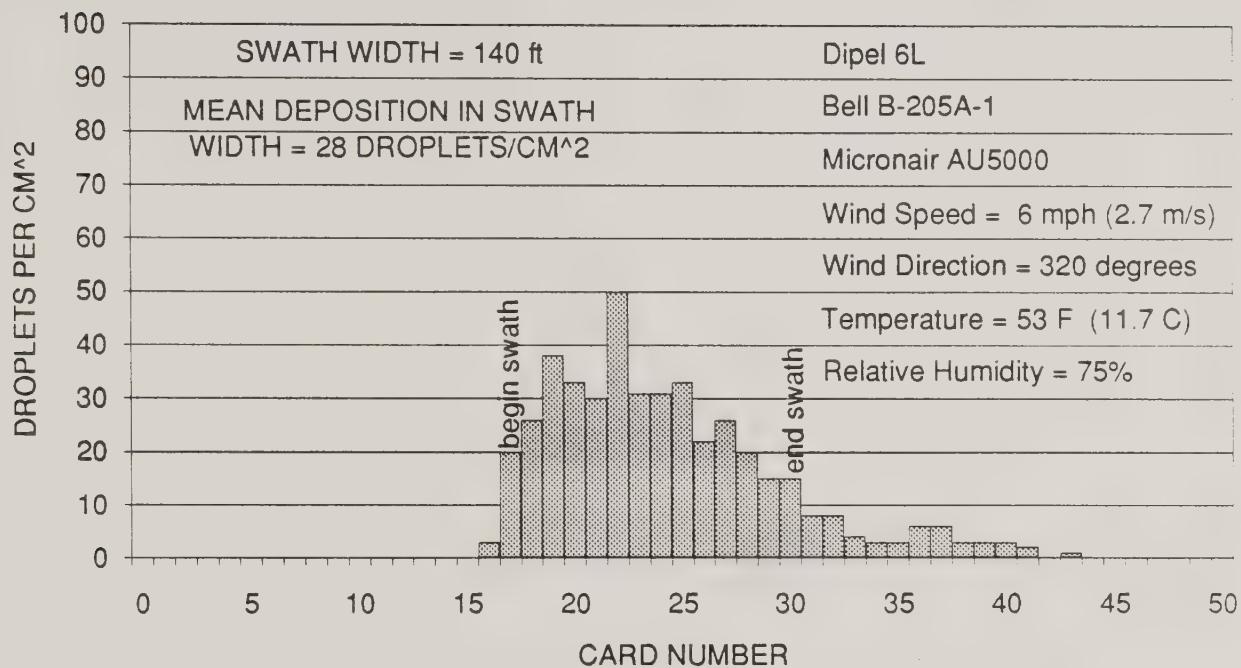
TRIAL 42 - GROUND CARD



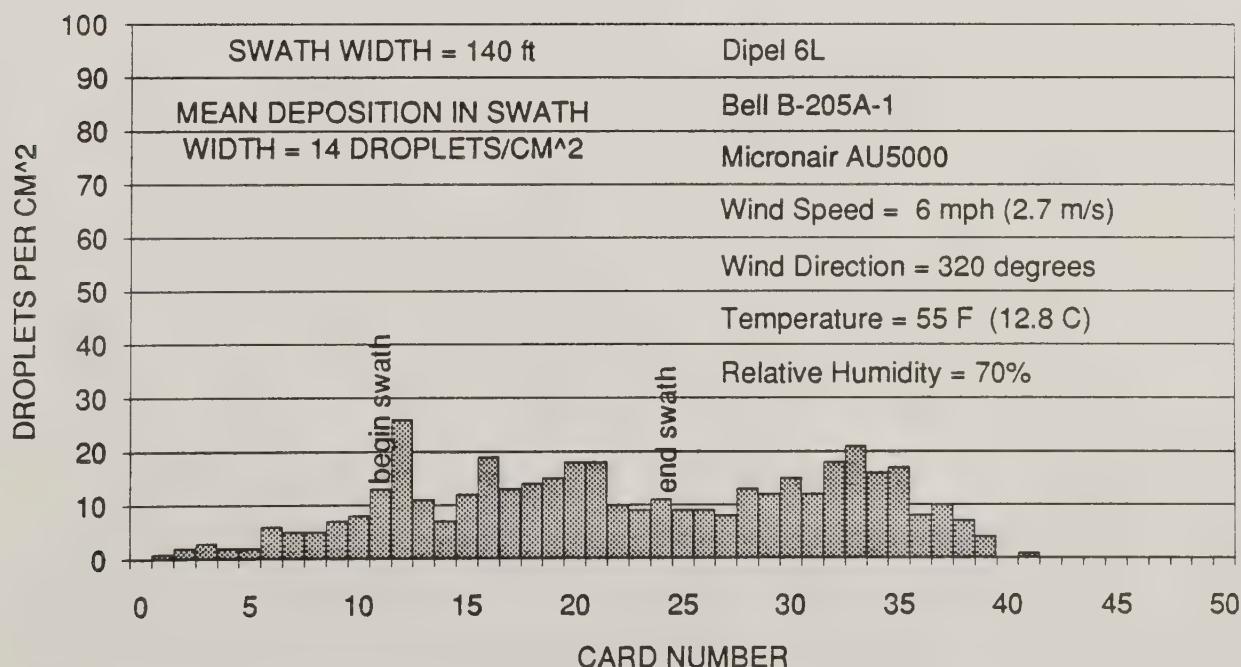
TRIAL 43 - GROUND CARD



TRIAL 44 - GROUND CARD



TRIAL 45 - GROUND CARD

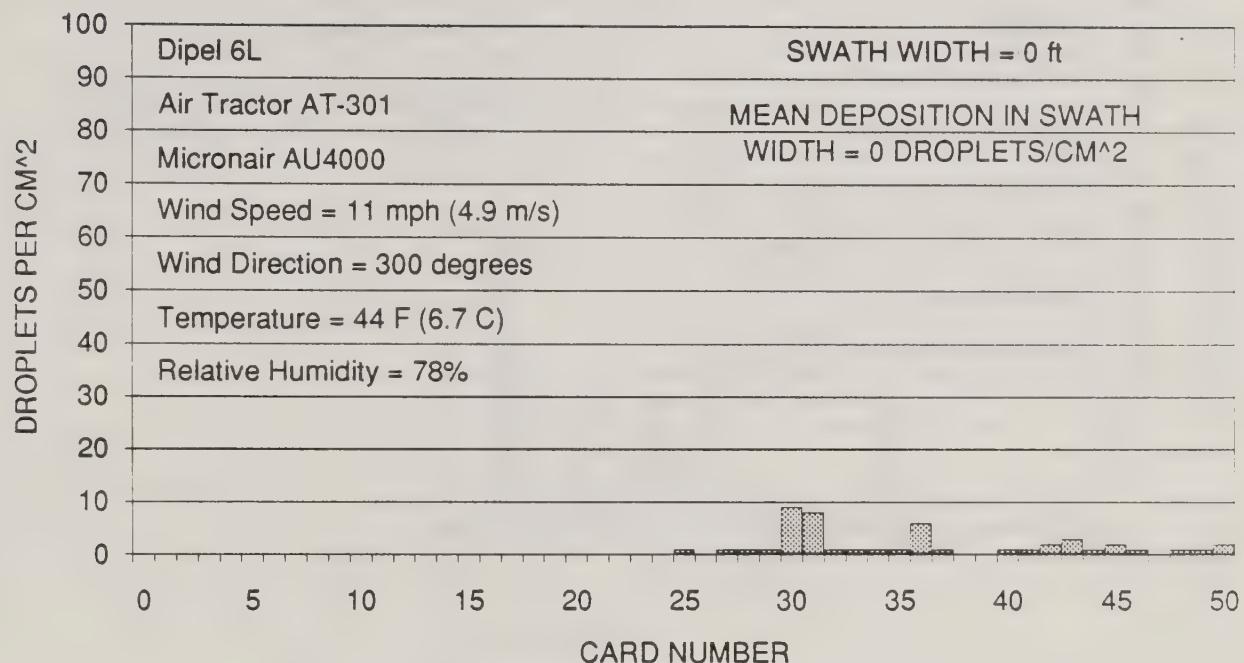


APPENDIX B

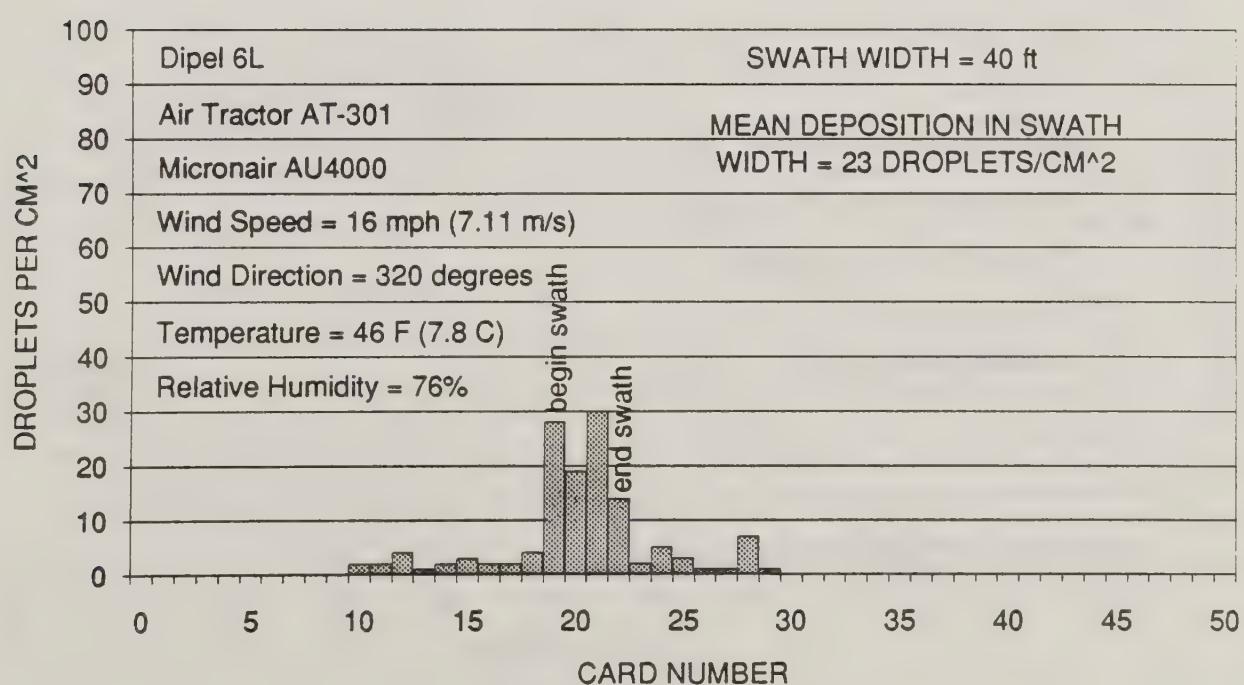
Trial Data and Stake Top Card Deposits in Tabular and Graphical Form

Appendix B - Trial data and stake top card deposits in tabular and graphical form

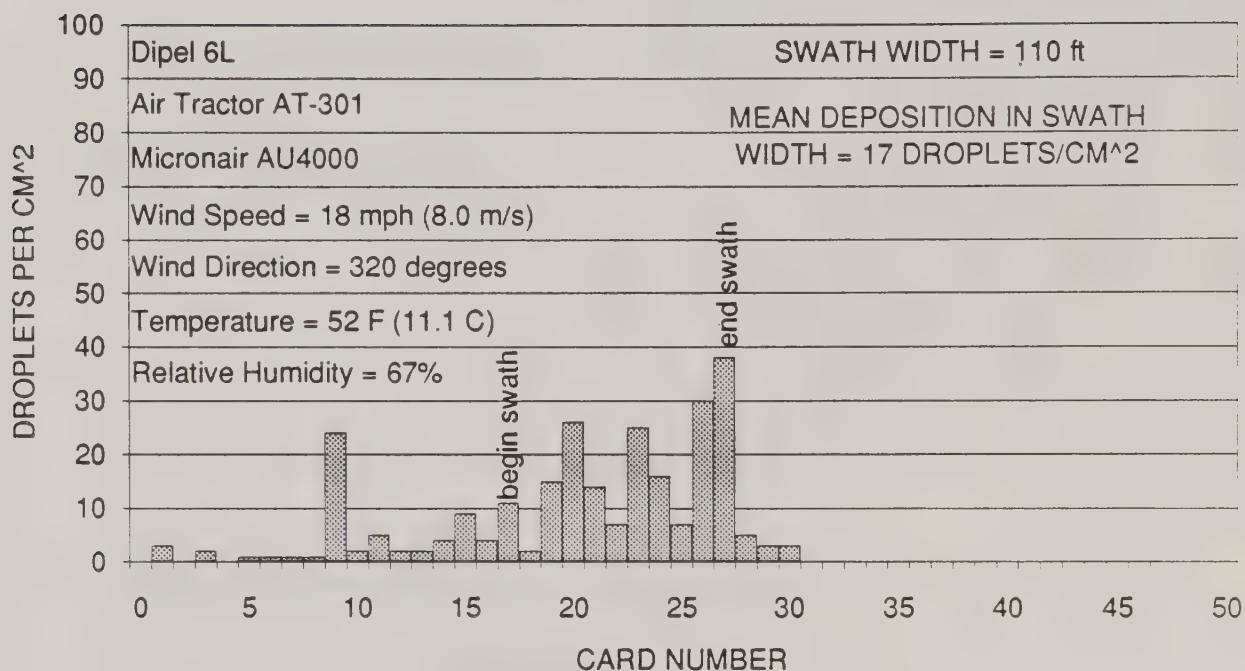
TRIAL 1 - STAKE TOP



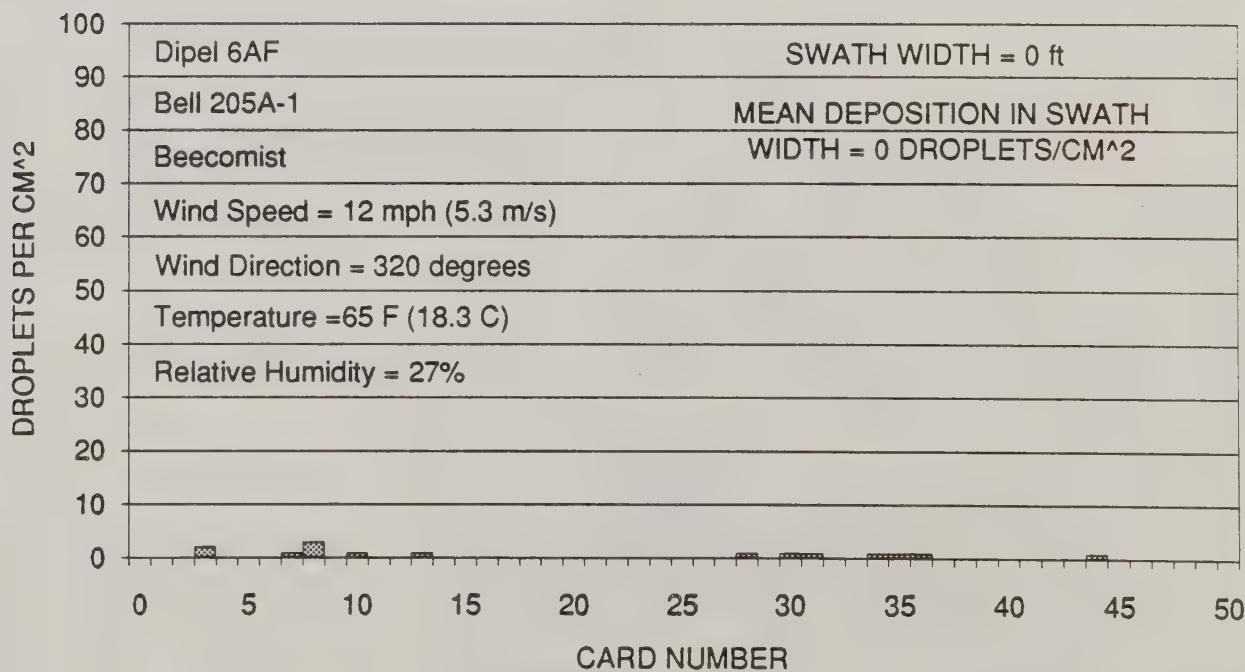
TRIAL 2 - STAKE TOP



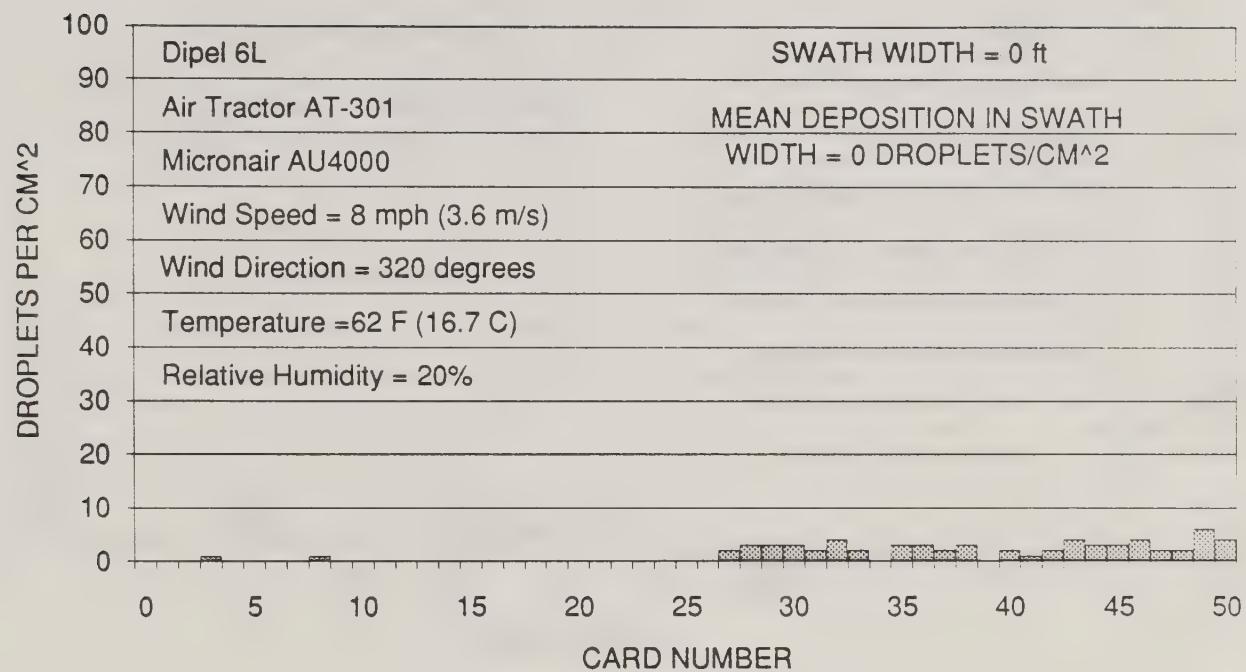
TRIAL 3 - STAKE TOP



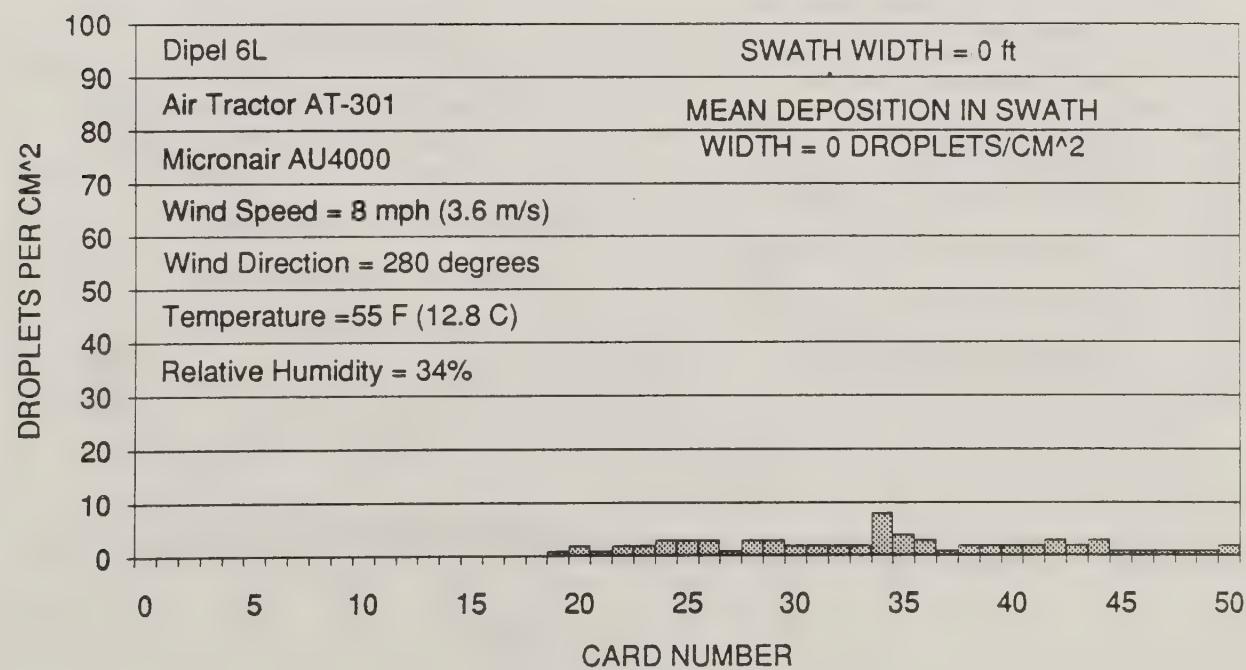
TRIAL 4 - STAKE TOP



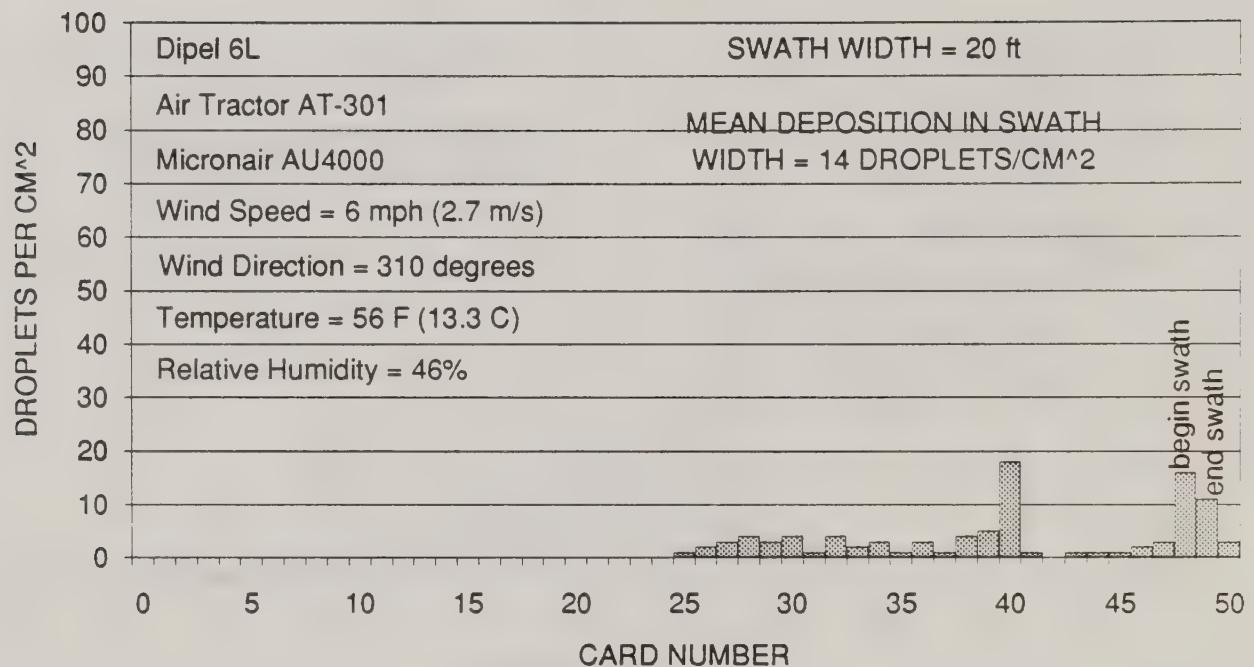
TRIAL 5 - STAKE TOP



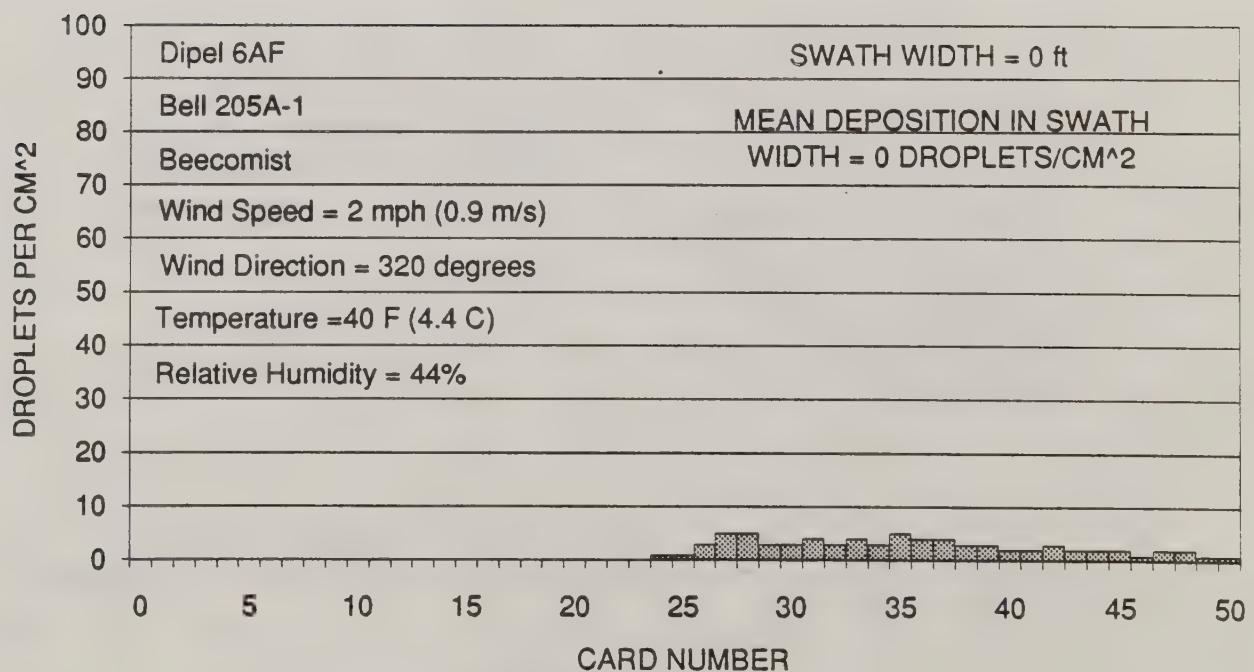
TRIAL 6 - STAKE TOP



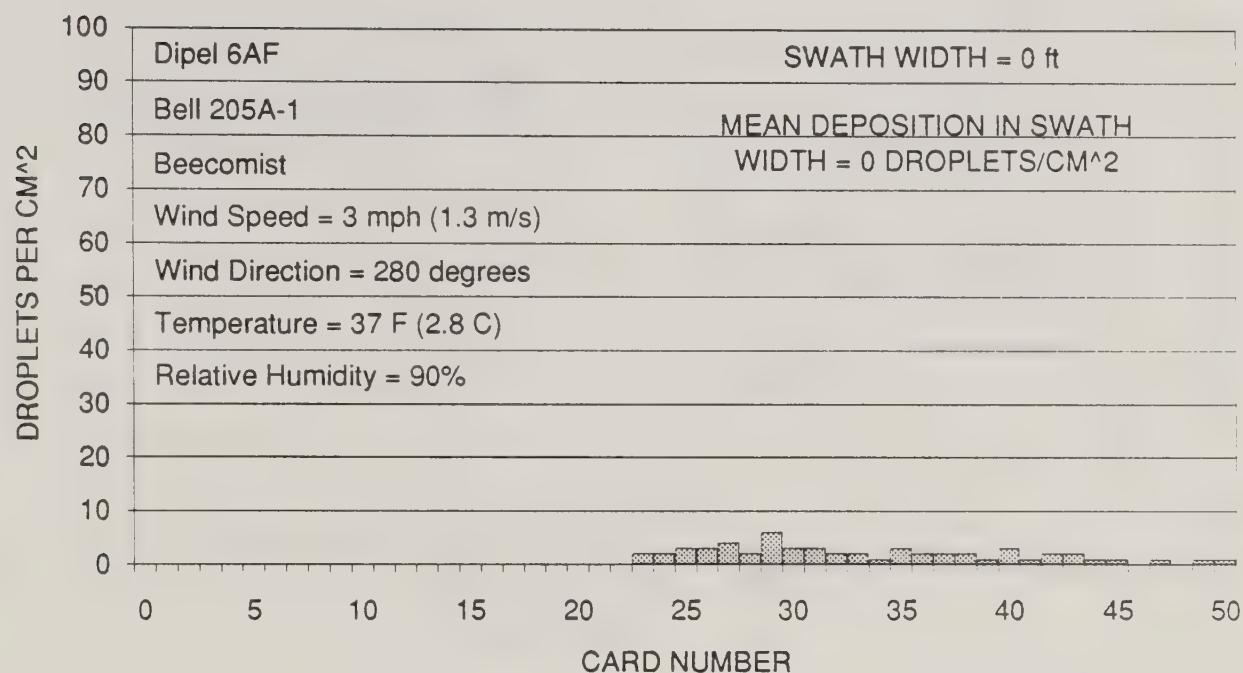
TRIAL 7 - STAKE TOP



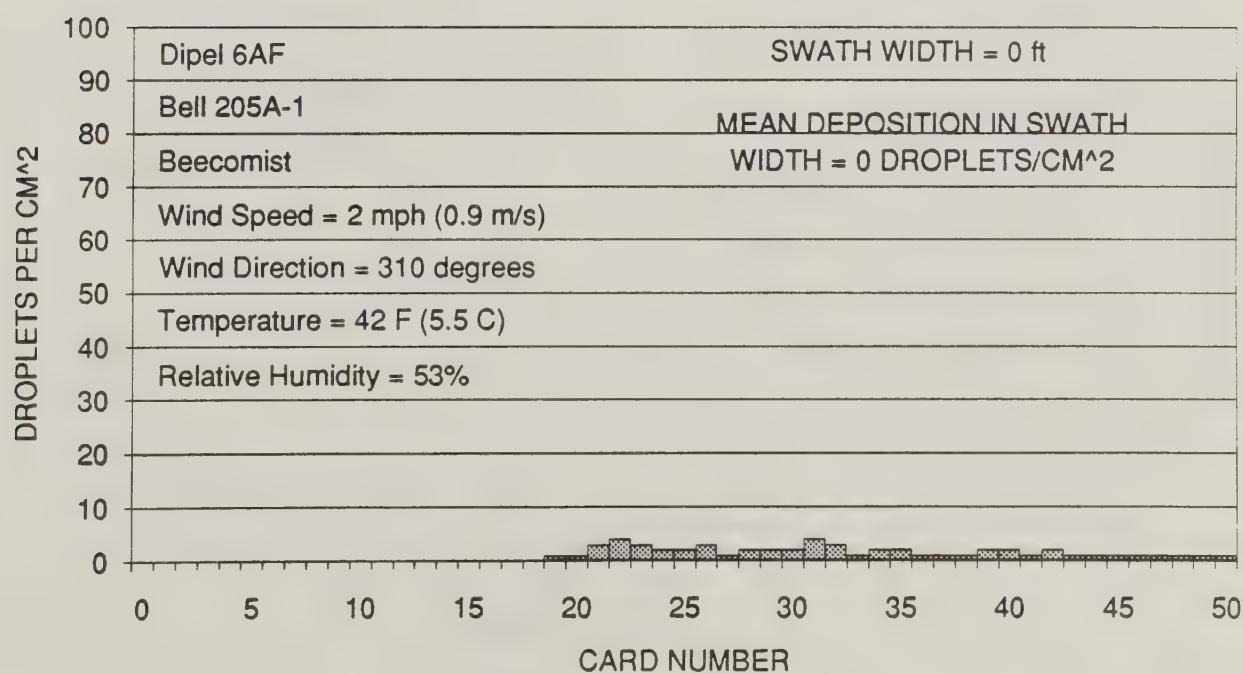
TRIAL 8 - STAKE TOP



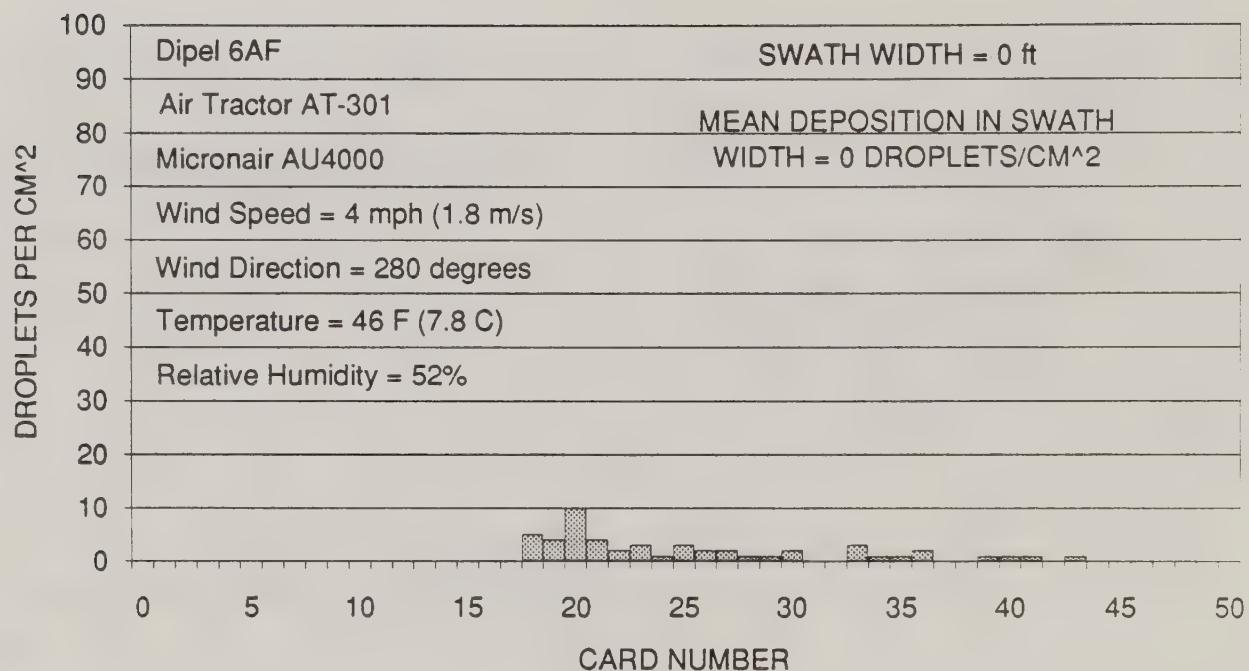
TRIAL 9 - STAKE TOP



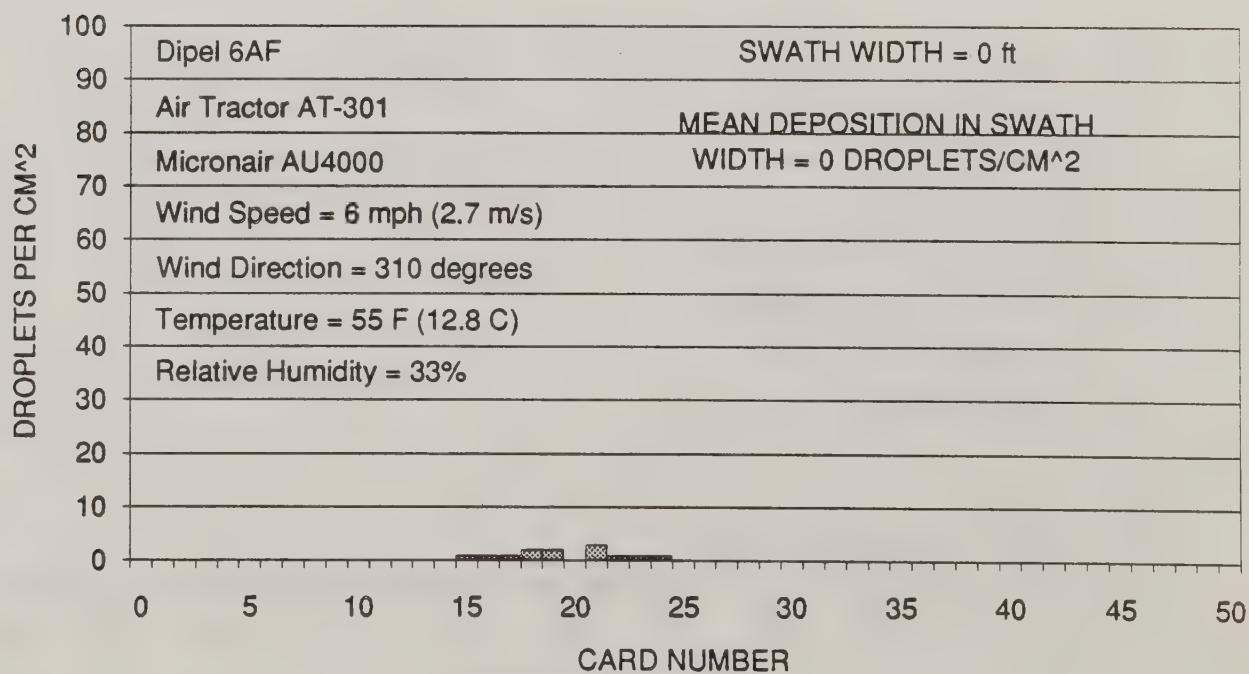
TRIAL 10 - STAKE TOP



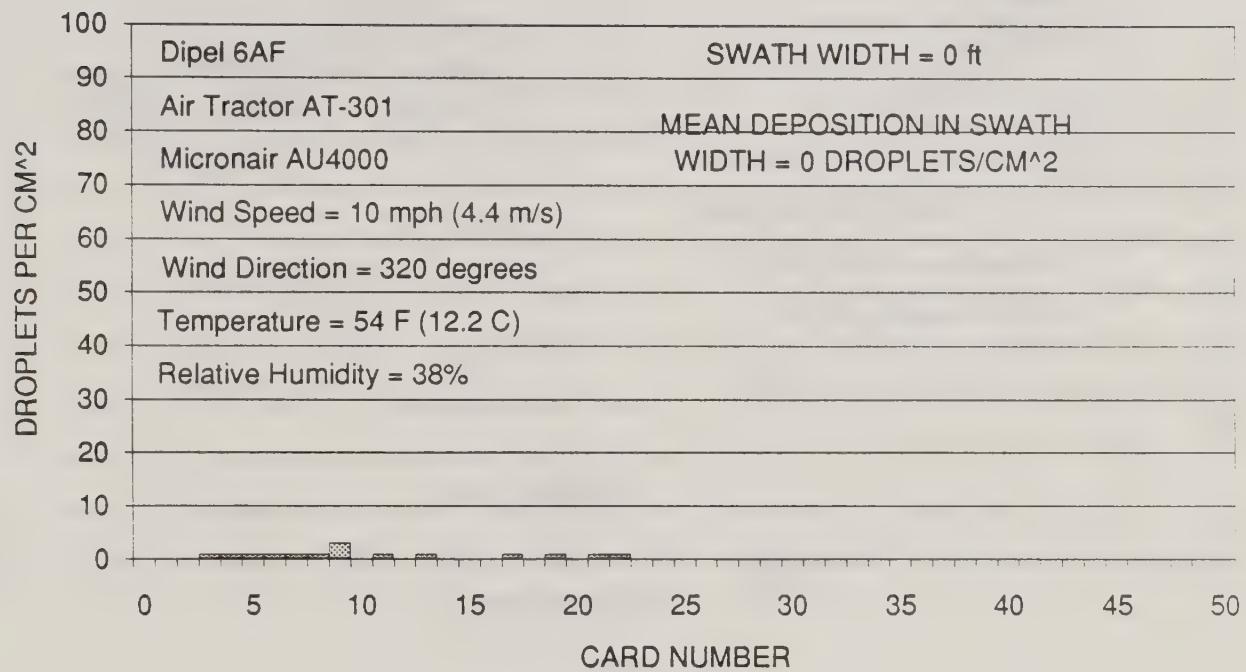
TRIAL 11 - STAKE TOP



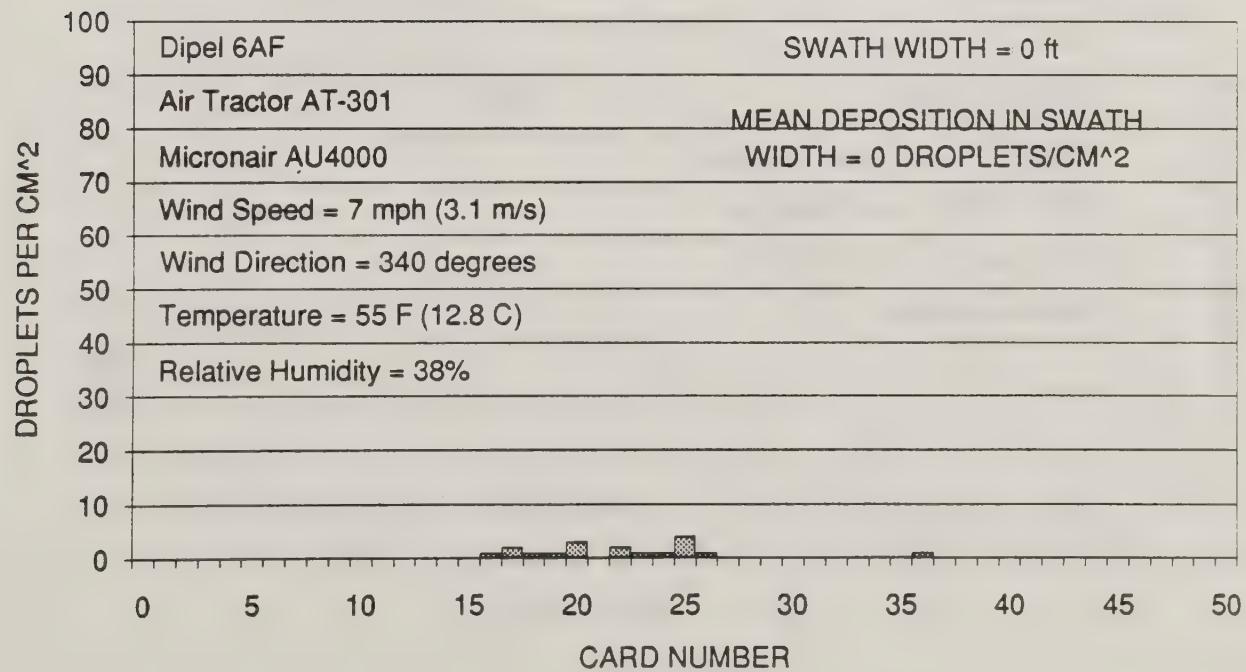
TRIAL 12 - STAKE TOP



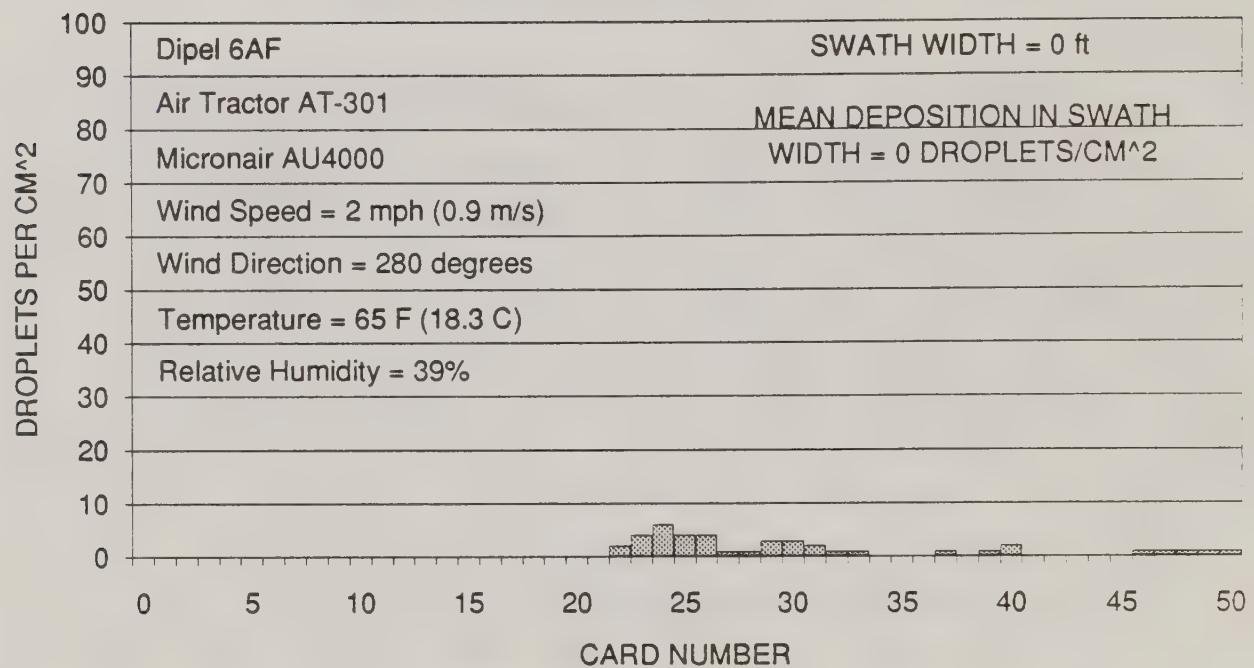
TRIAL 13 - STAKE TOP



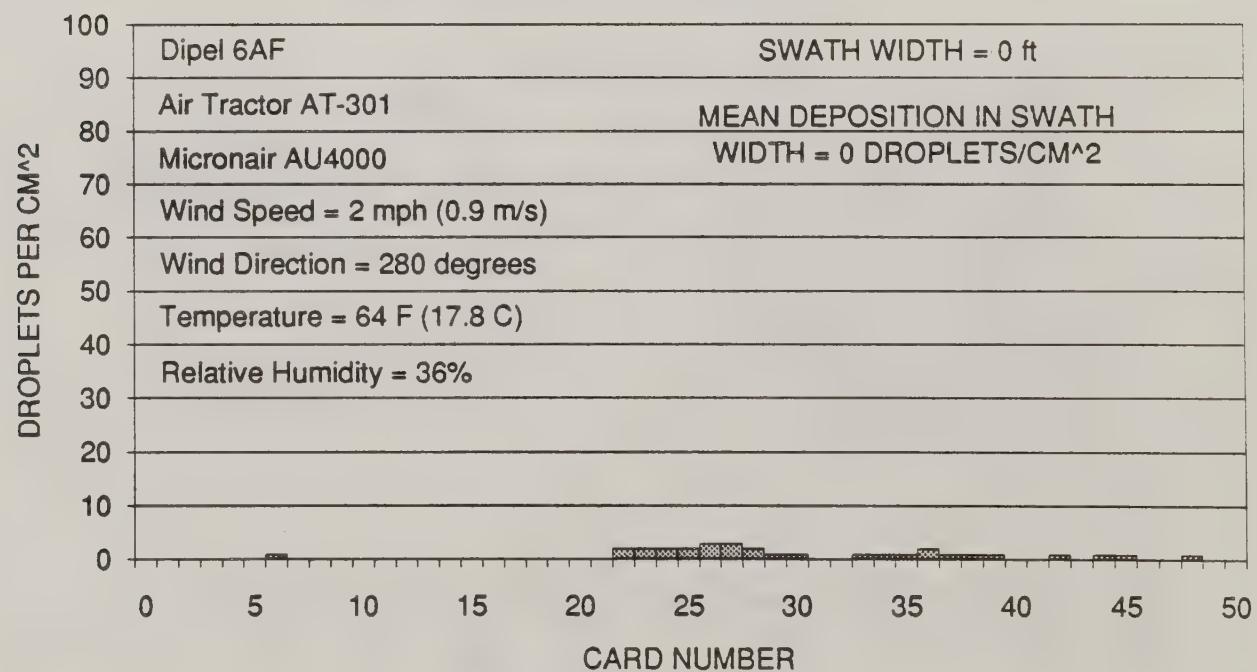
TRIAL 14 - STAKE TOP



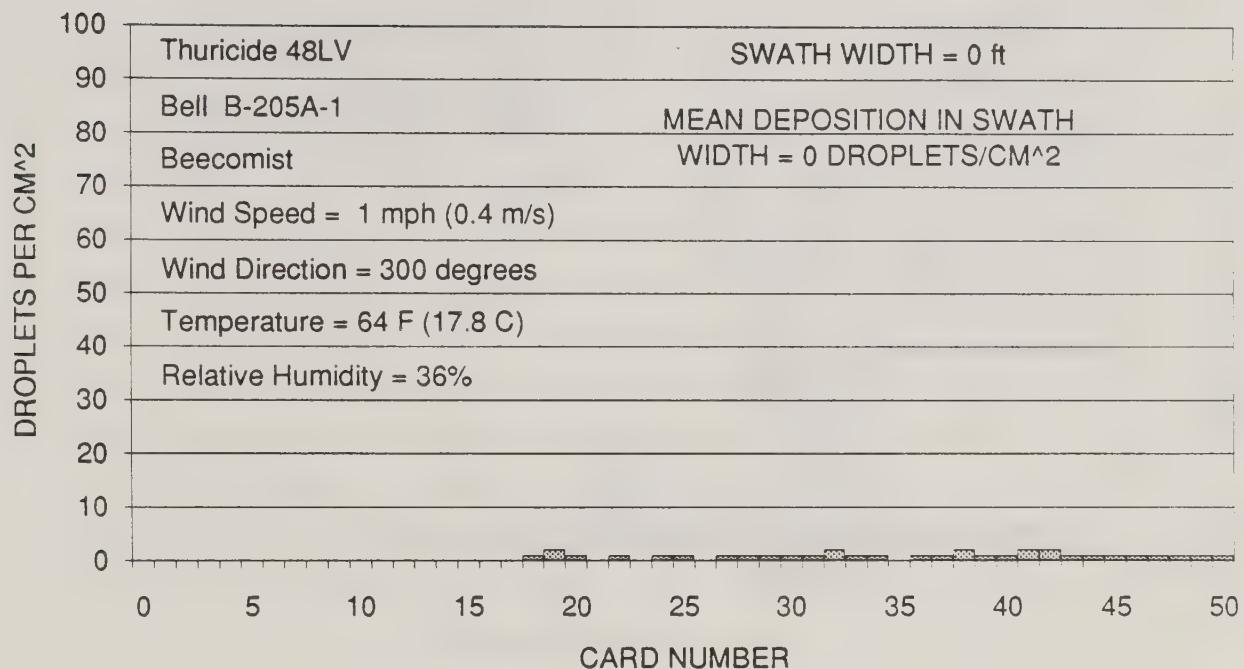
TRIAL 15 - STAKE TOP



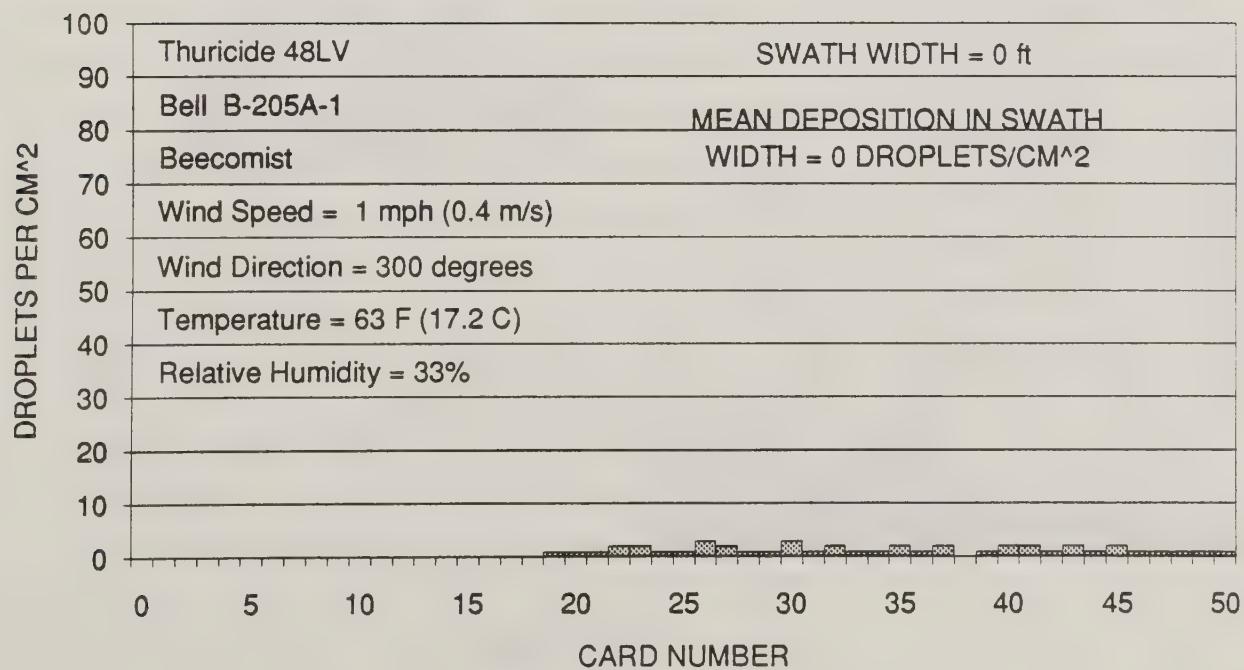
TRIAL 16 - STAKE TOP



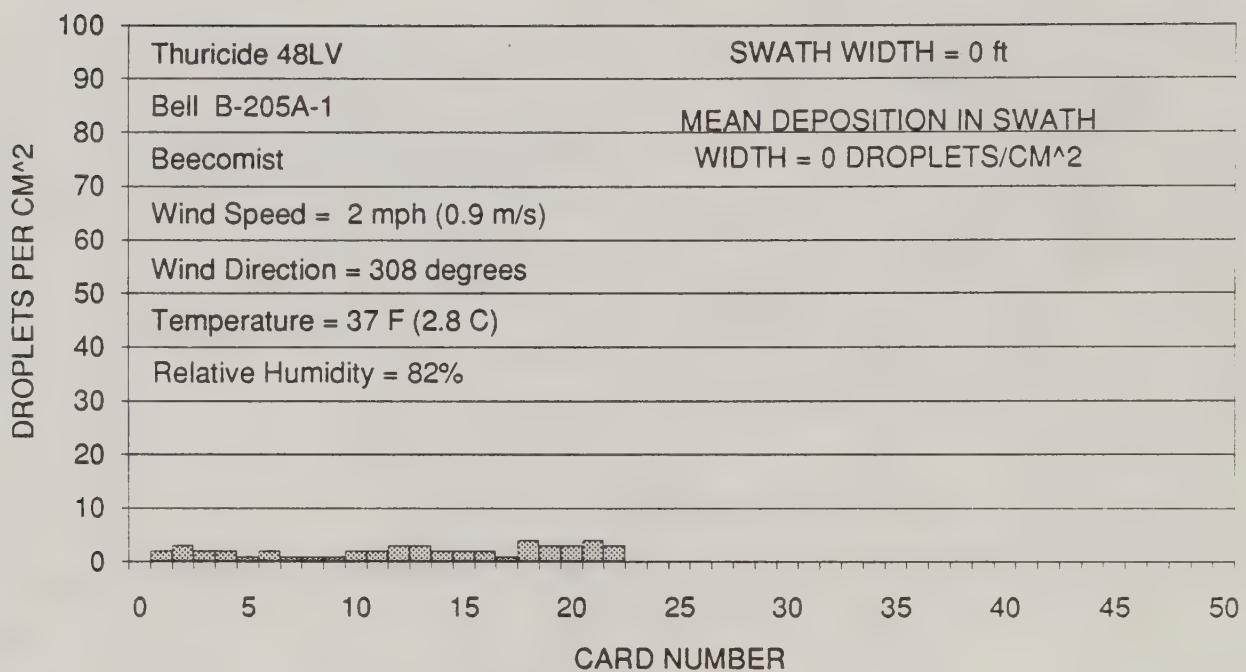
TRIAL 17 - STAKE TOP



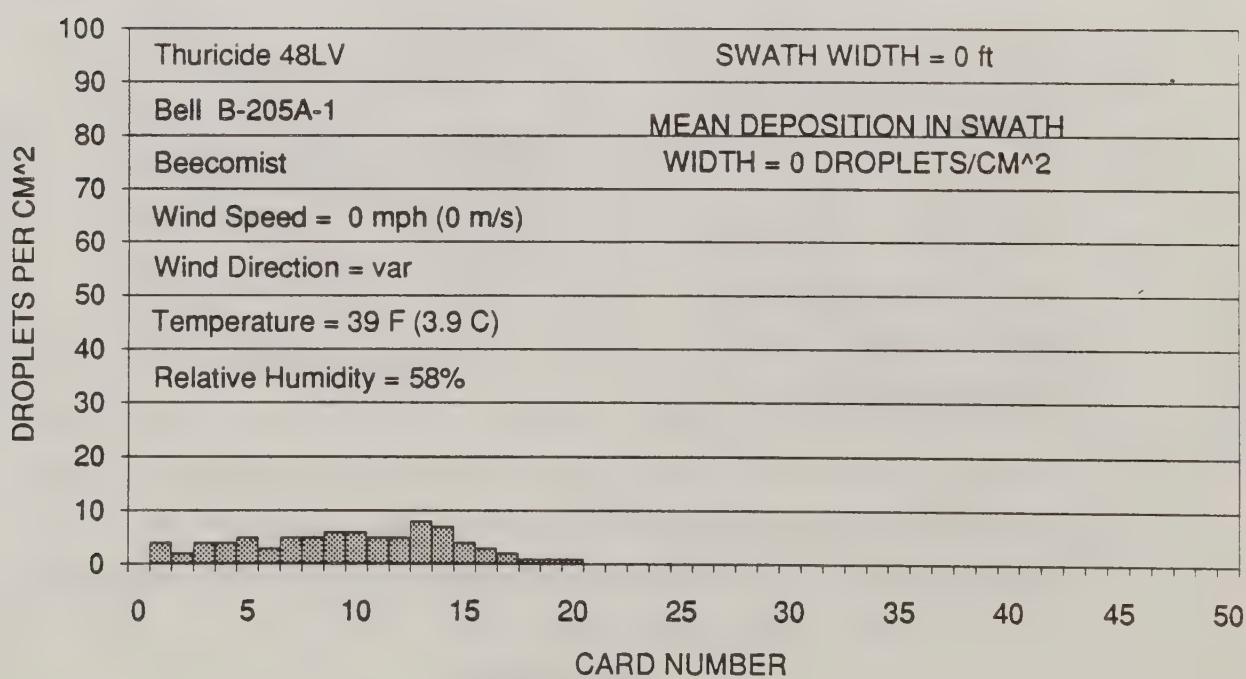
TRIAL 18 - STAKE TOP



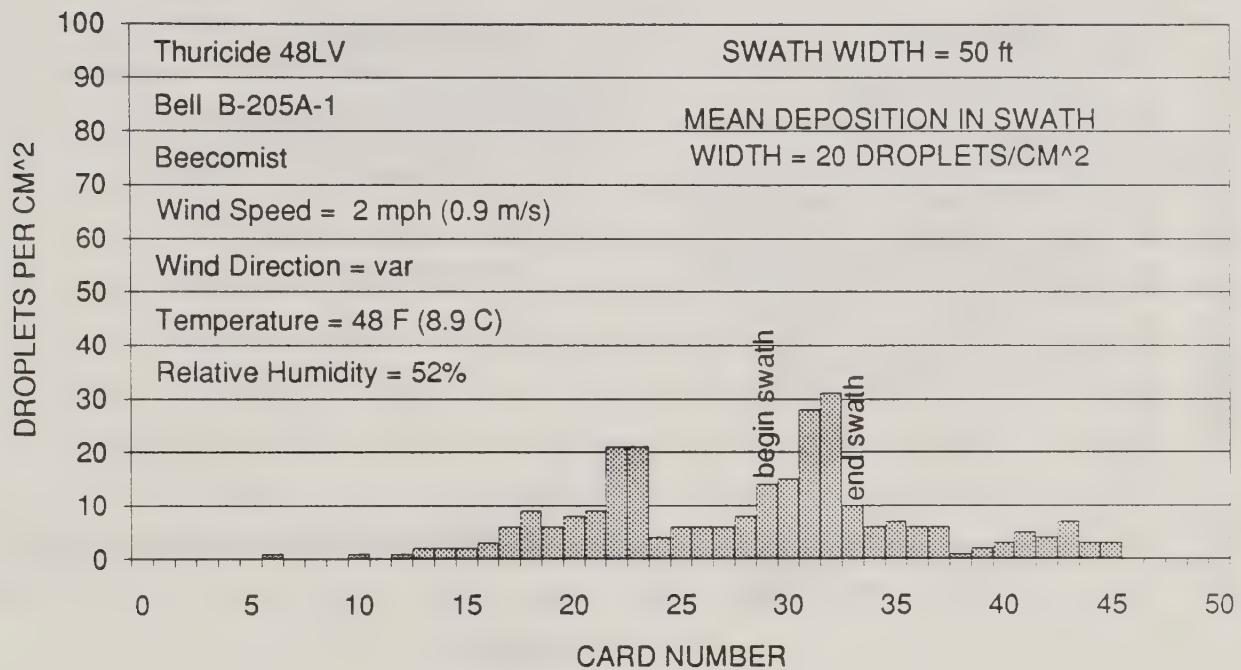
TRIAL 19 - STAKE TOP



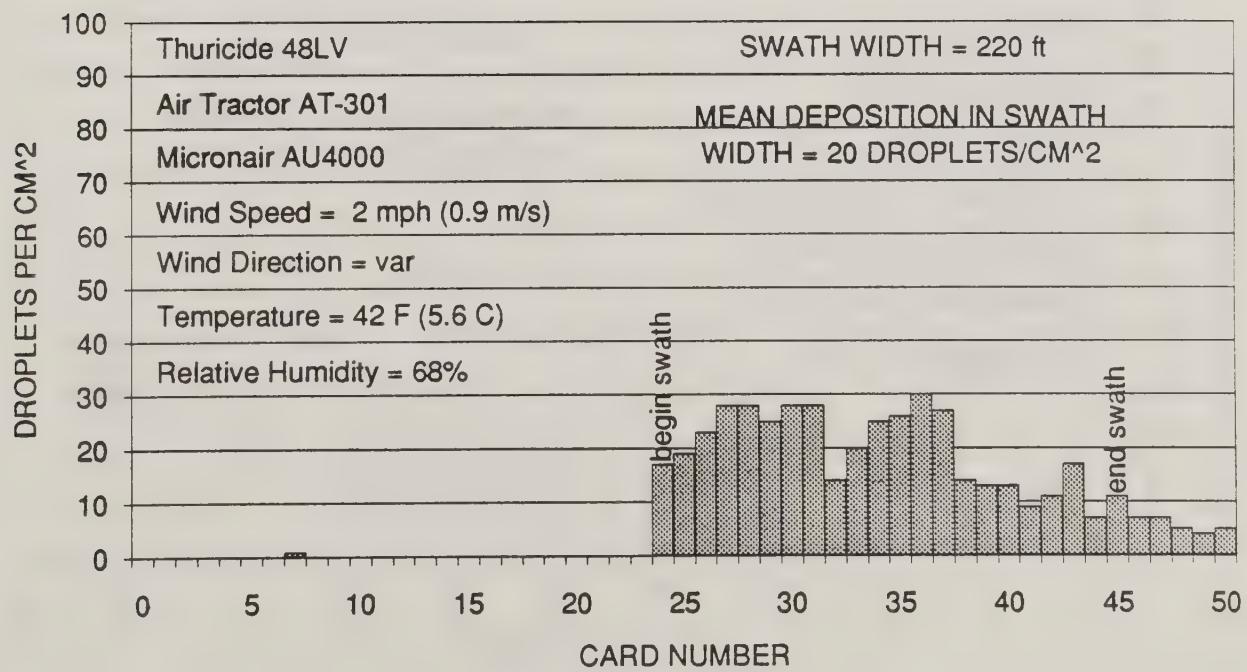
TRIAL 20 - STAKE TOP



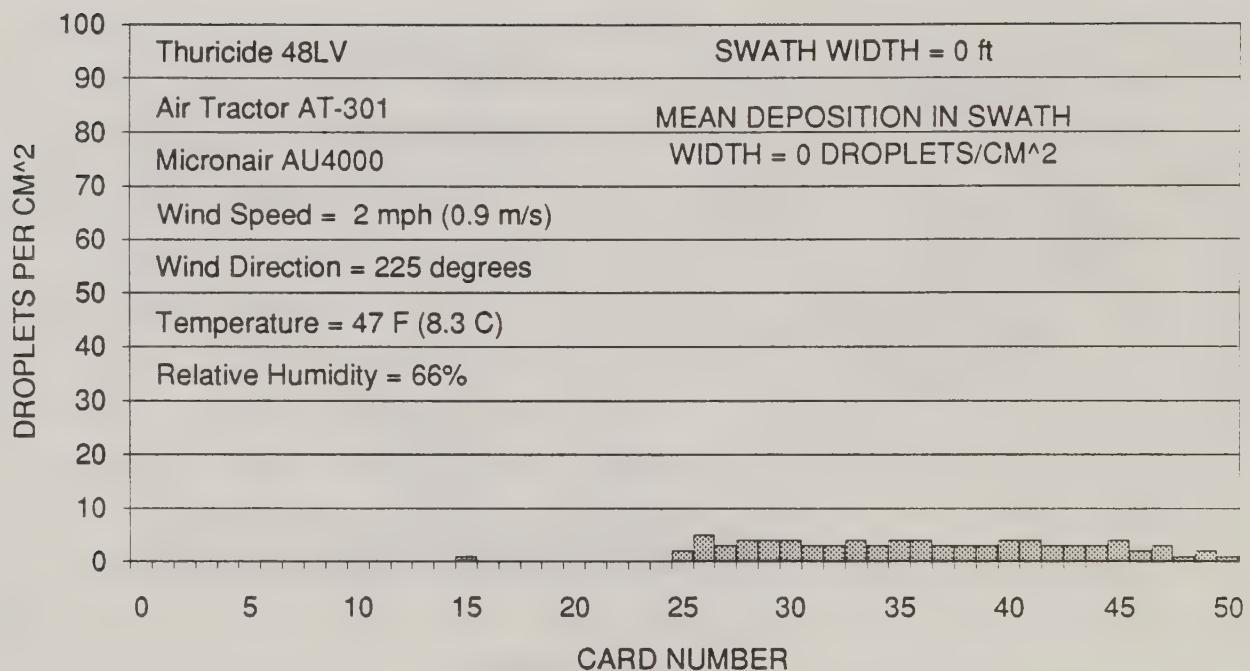
TRIAL 21 - STAKE TOP



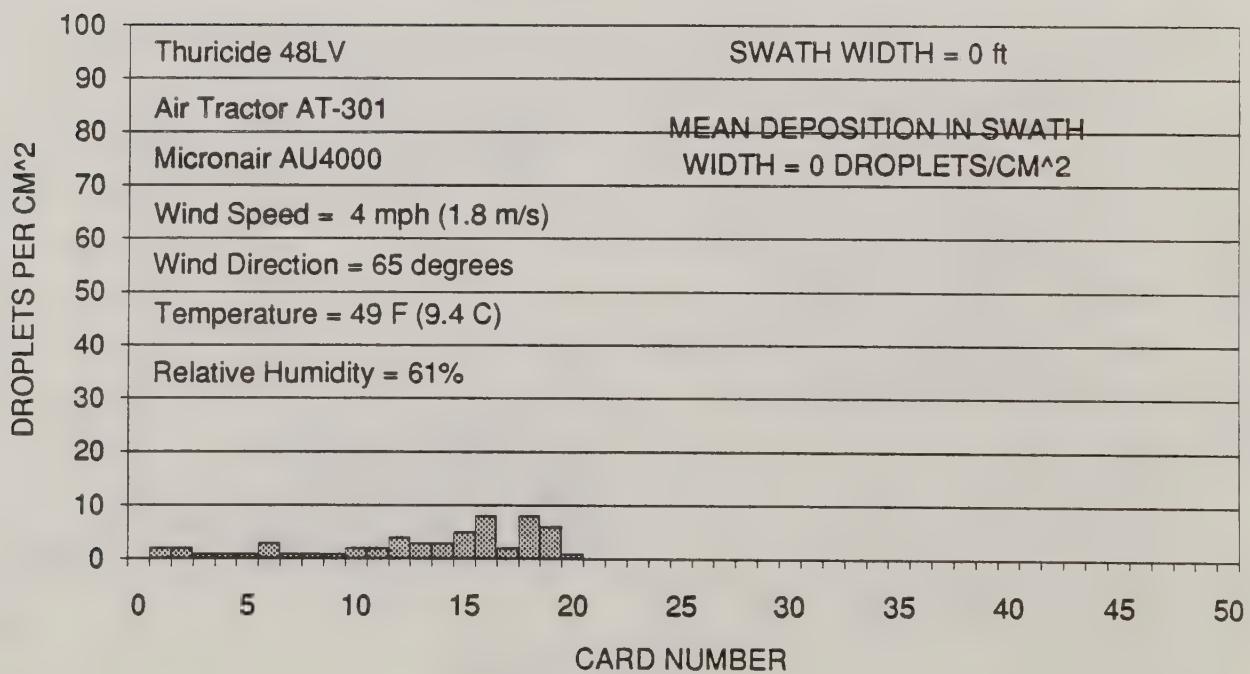
TRIAL 22 - STAKE TOP



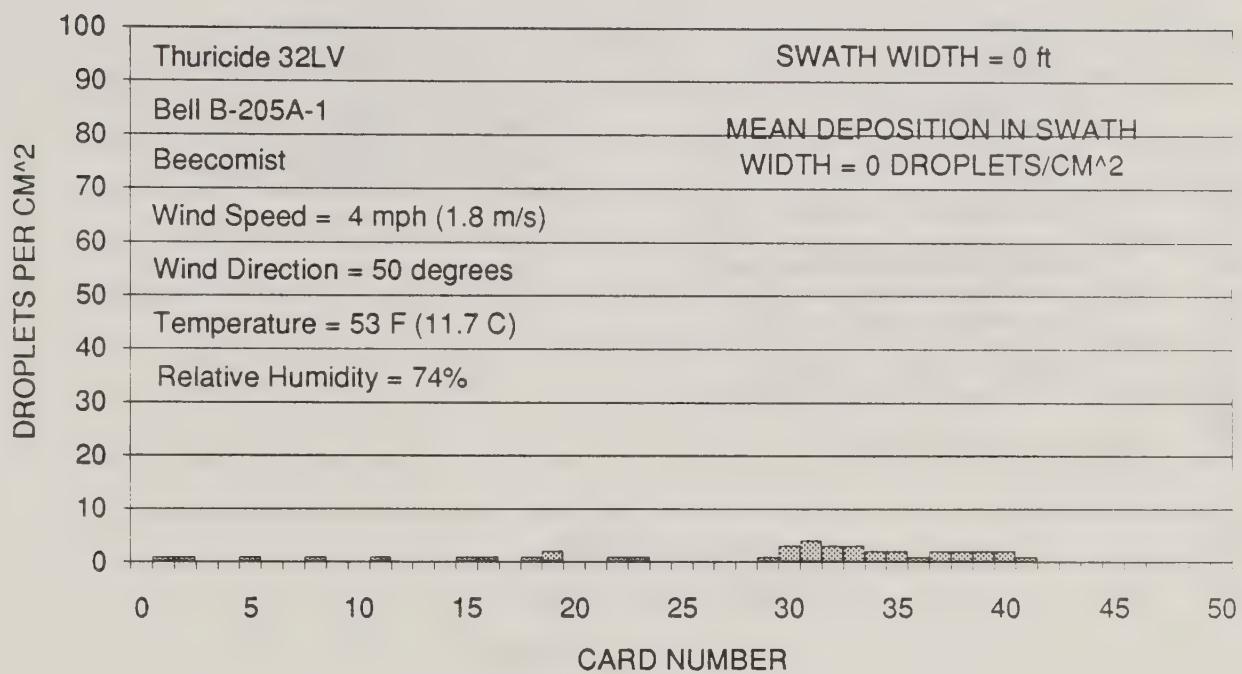
TRIAL 23 - STAKE TOP



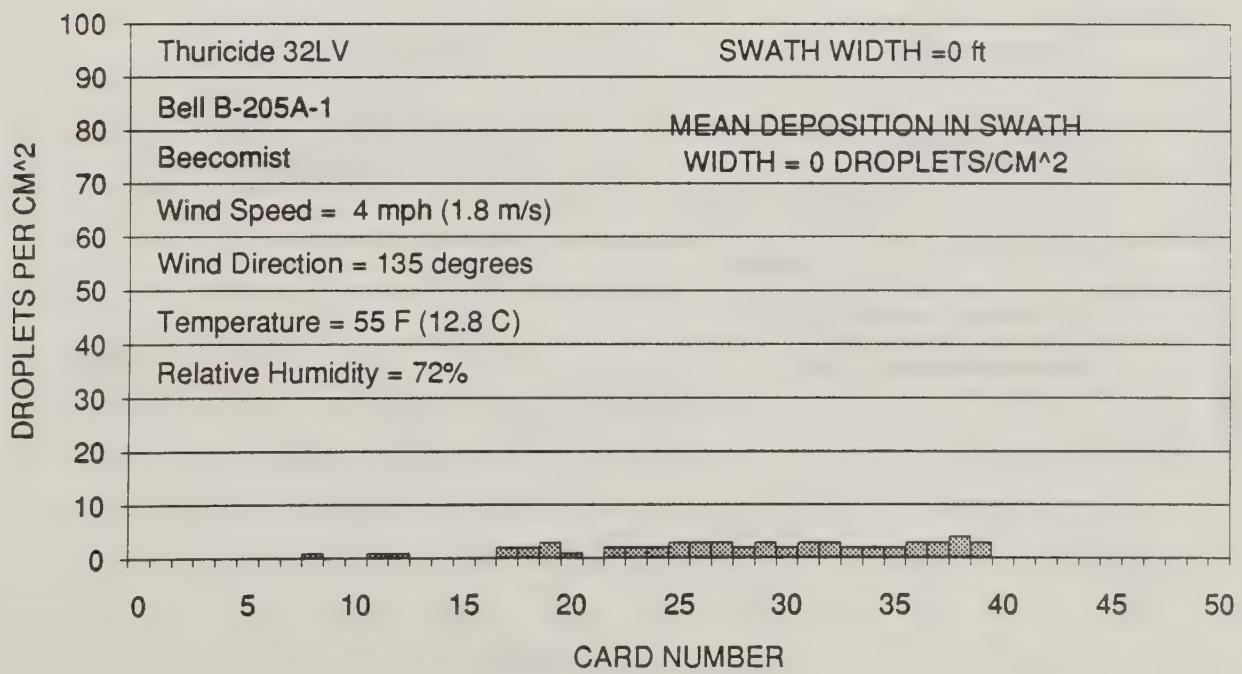
TRIAL 24 - STAKE TOP



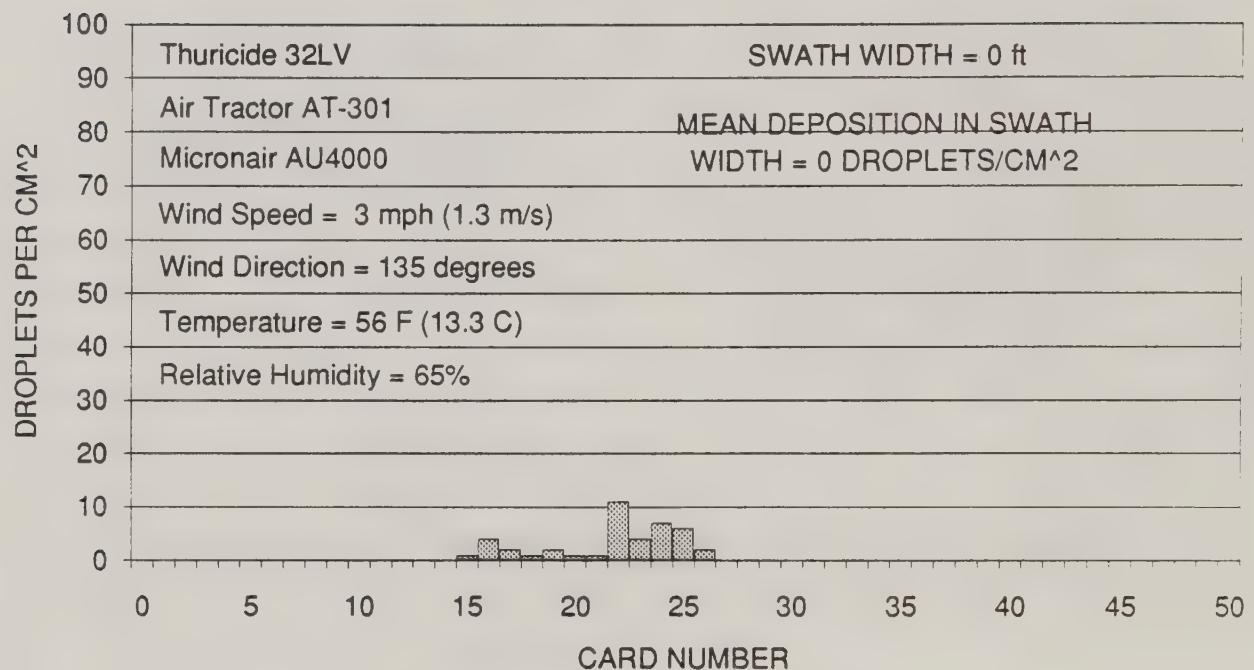
TRIAL 25 - STAKE TOP



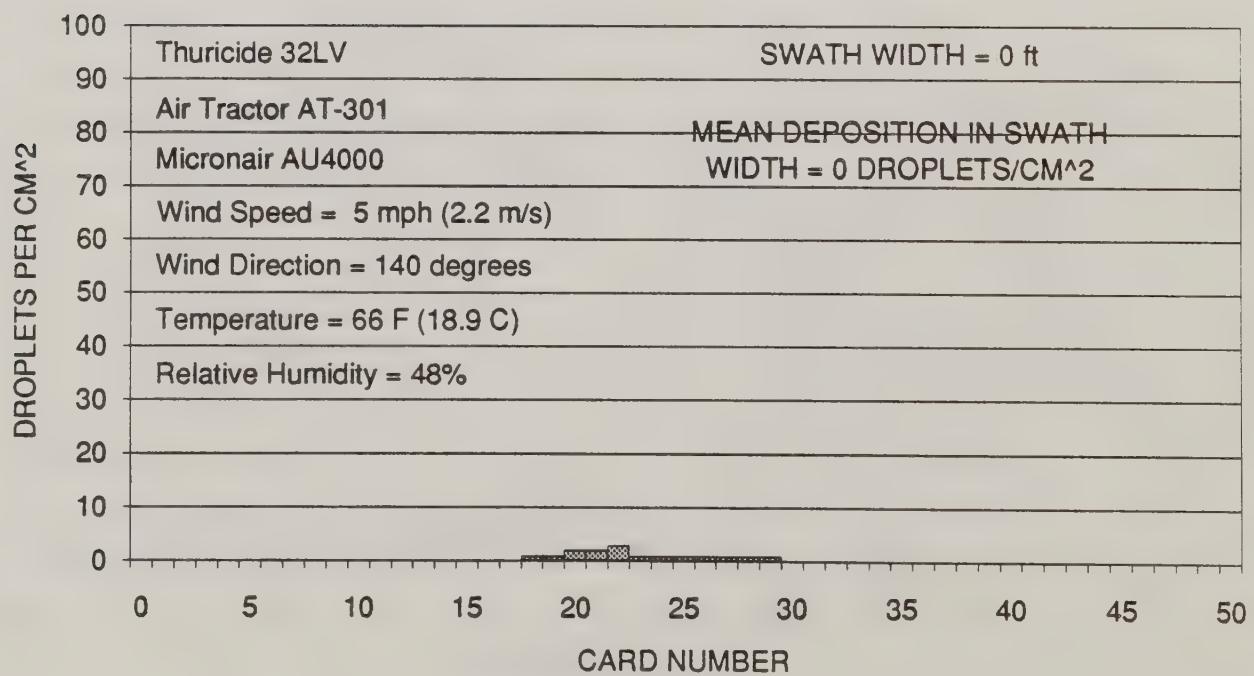
TRIAL 26 - STAKE TOP



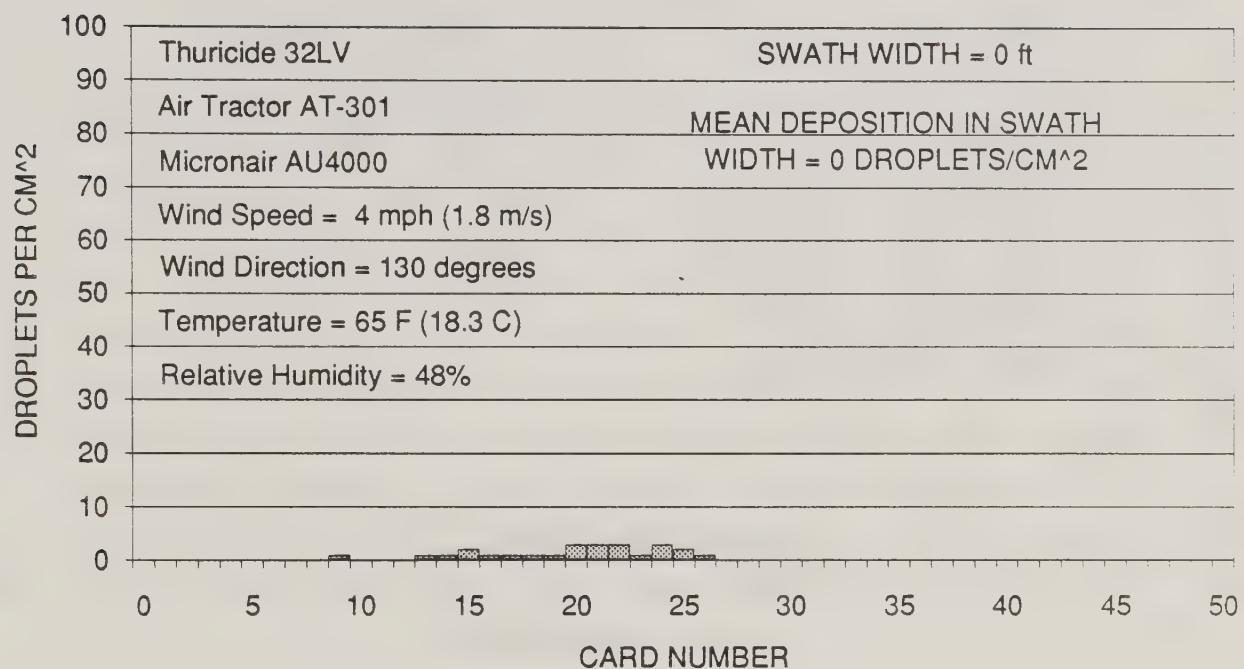
TRIAL 27 - STAKE TOP



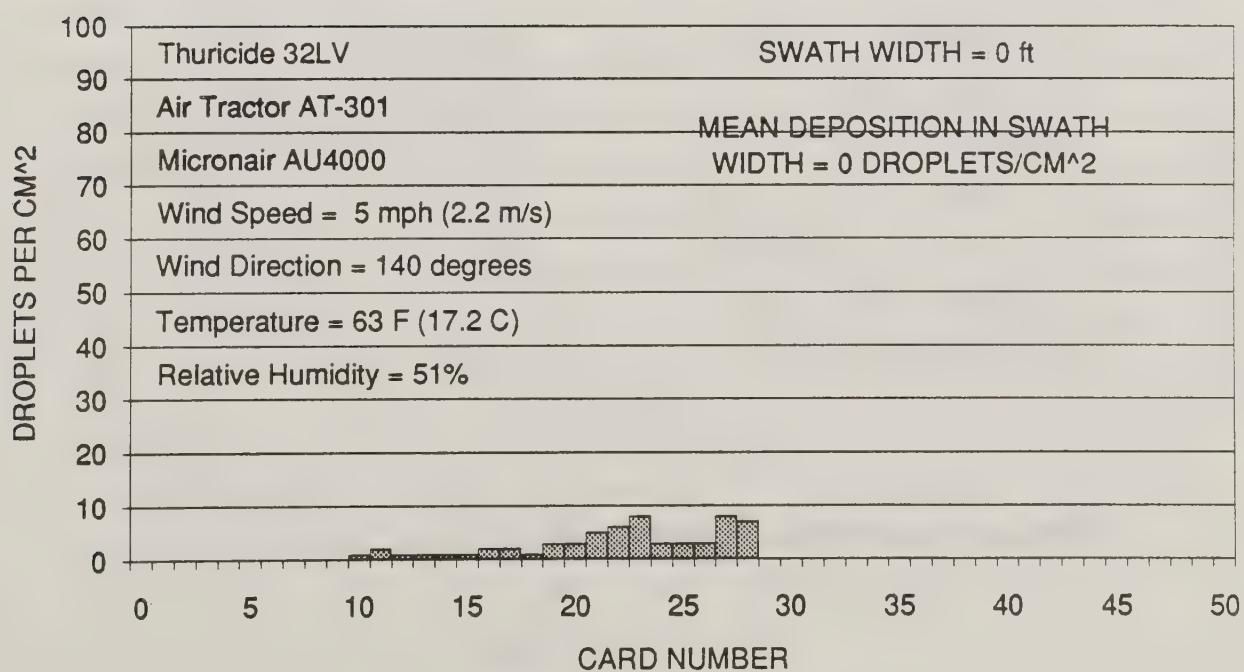
TRIAL 28 - STAKE TOP



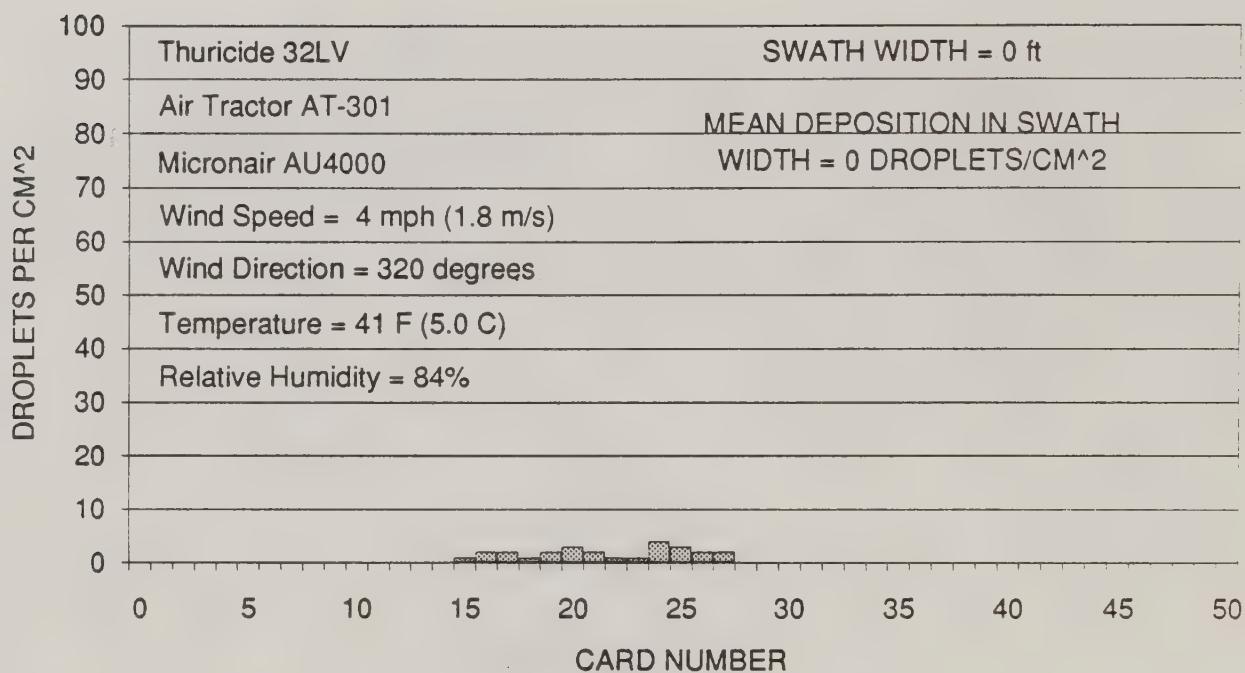
TRIAL 29 - STAKE TOP



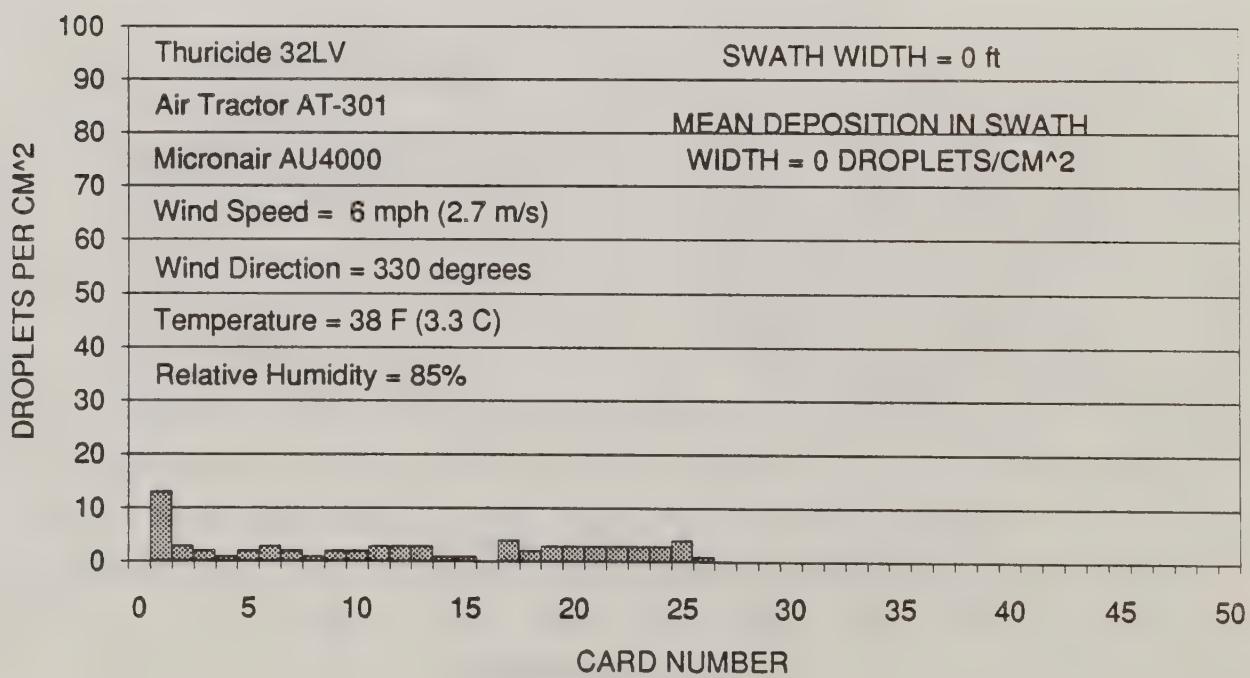
TRIAL 30 - STAKE TOP



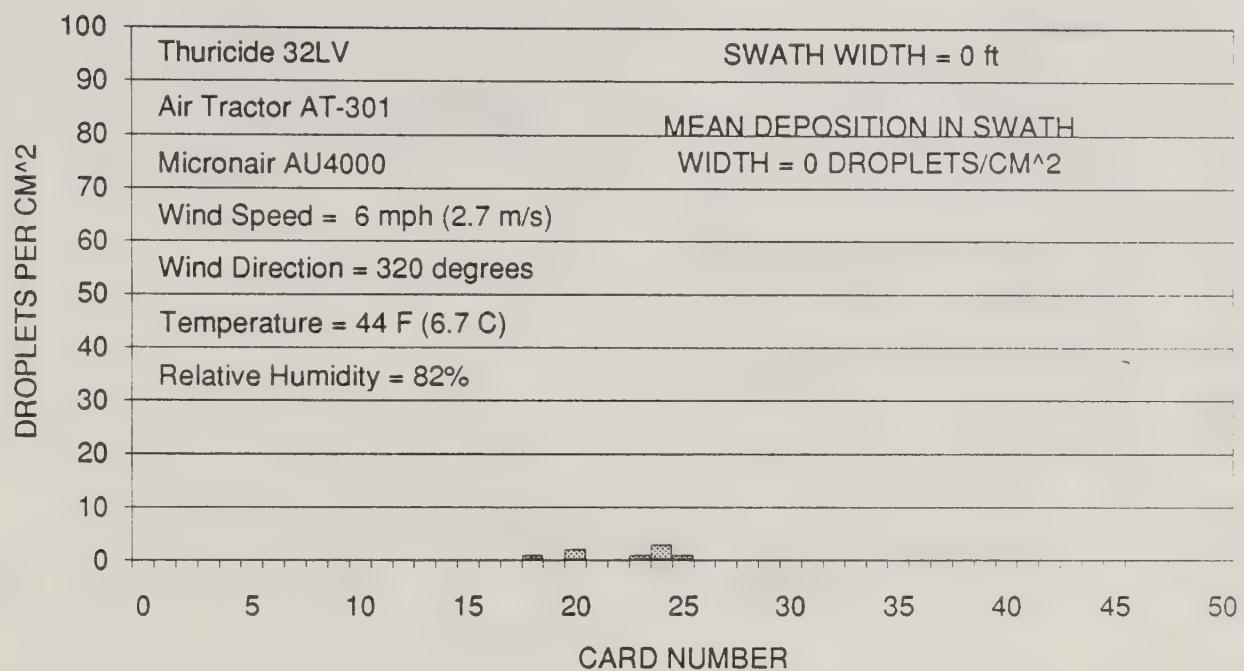
TRIAL 31 - STAKE TOP



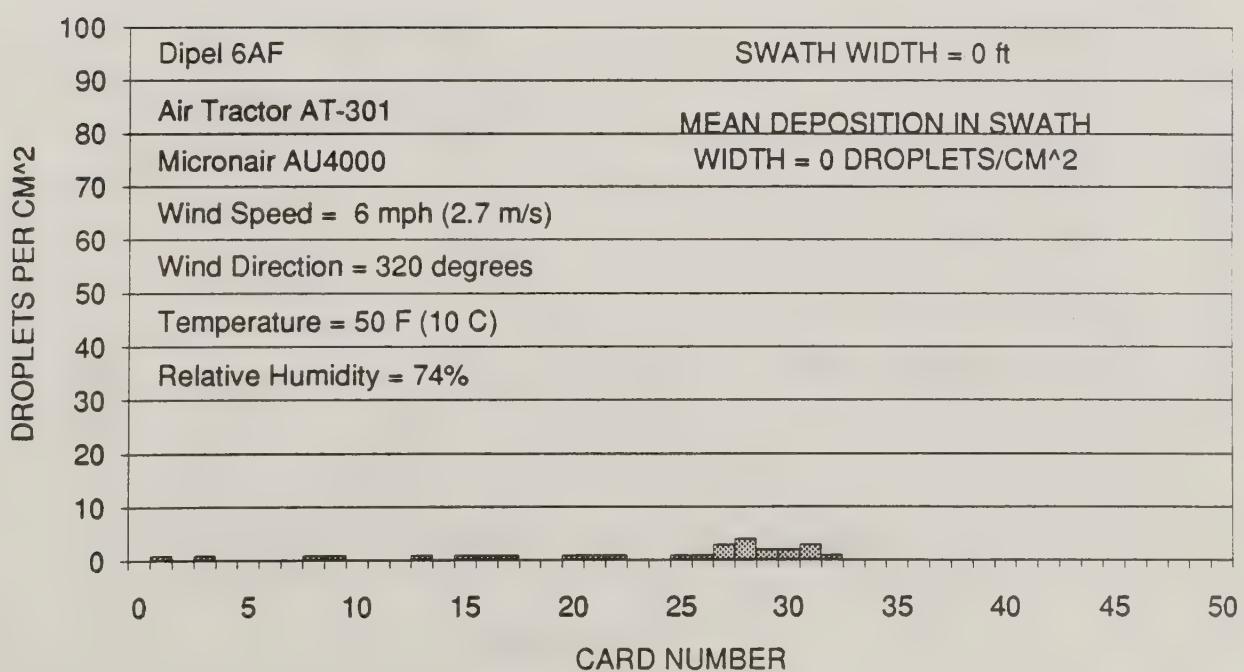
TRIAL 32 - STAKE TOP



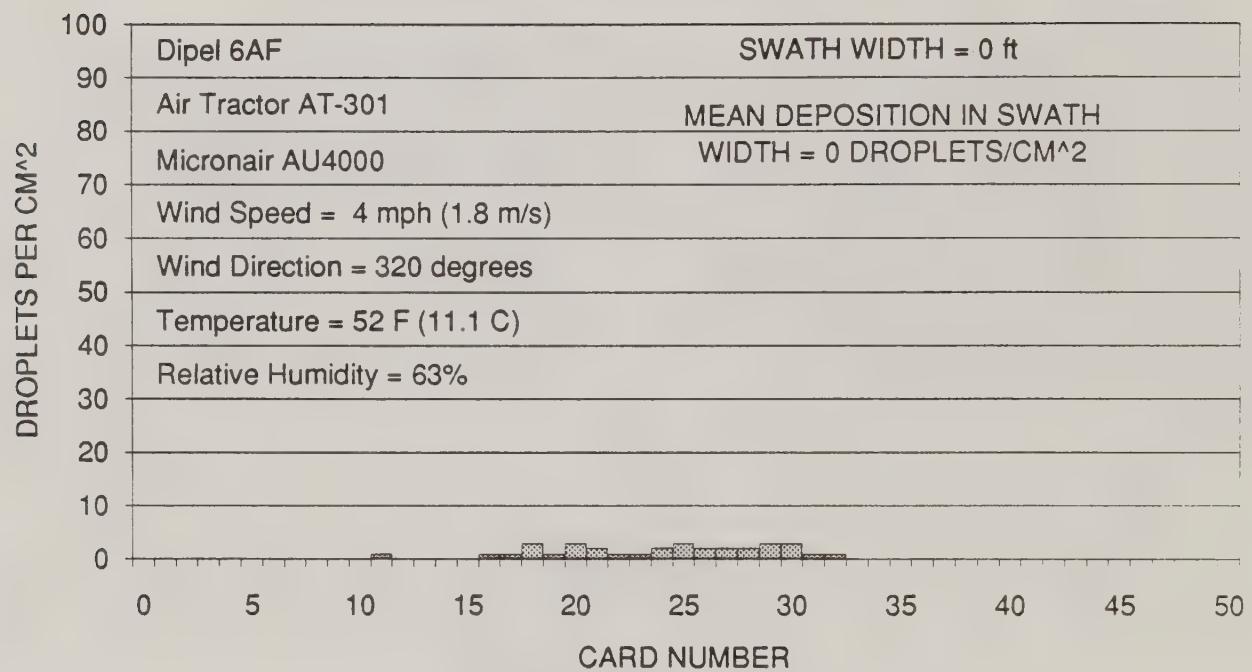
TRIAL 33 - STAKE TOP



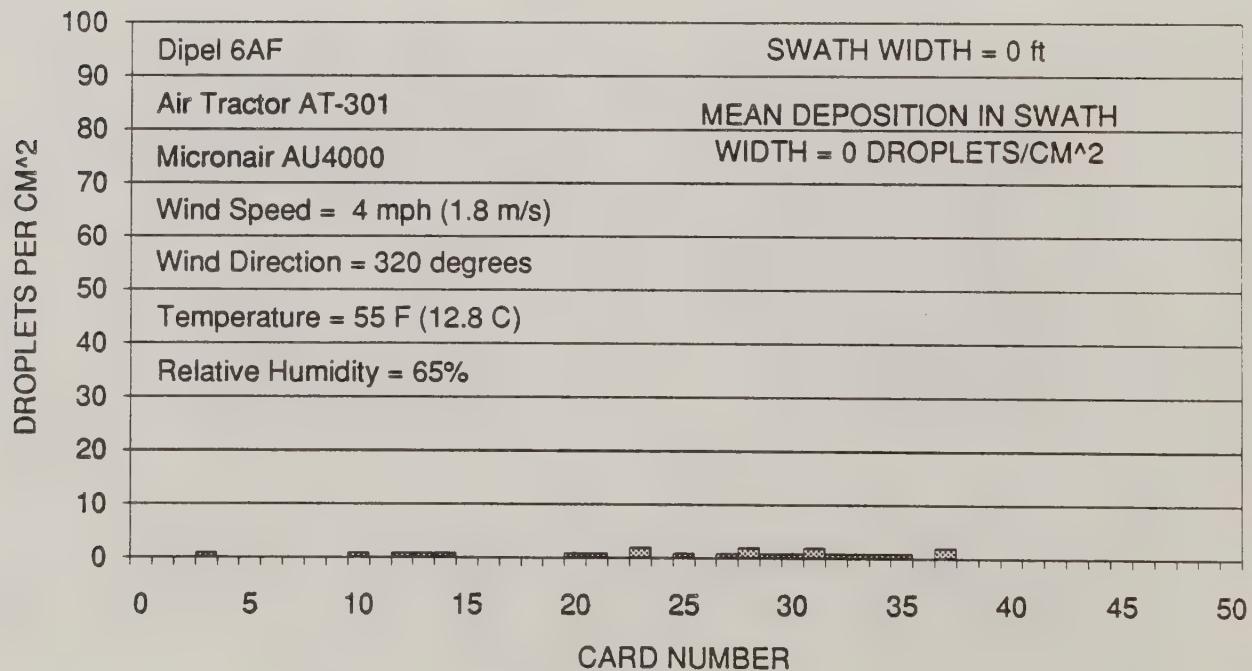
TRIAL 34 - STAKE TOP



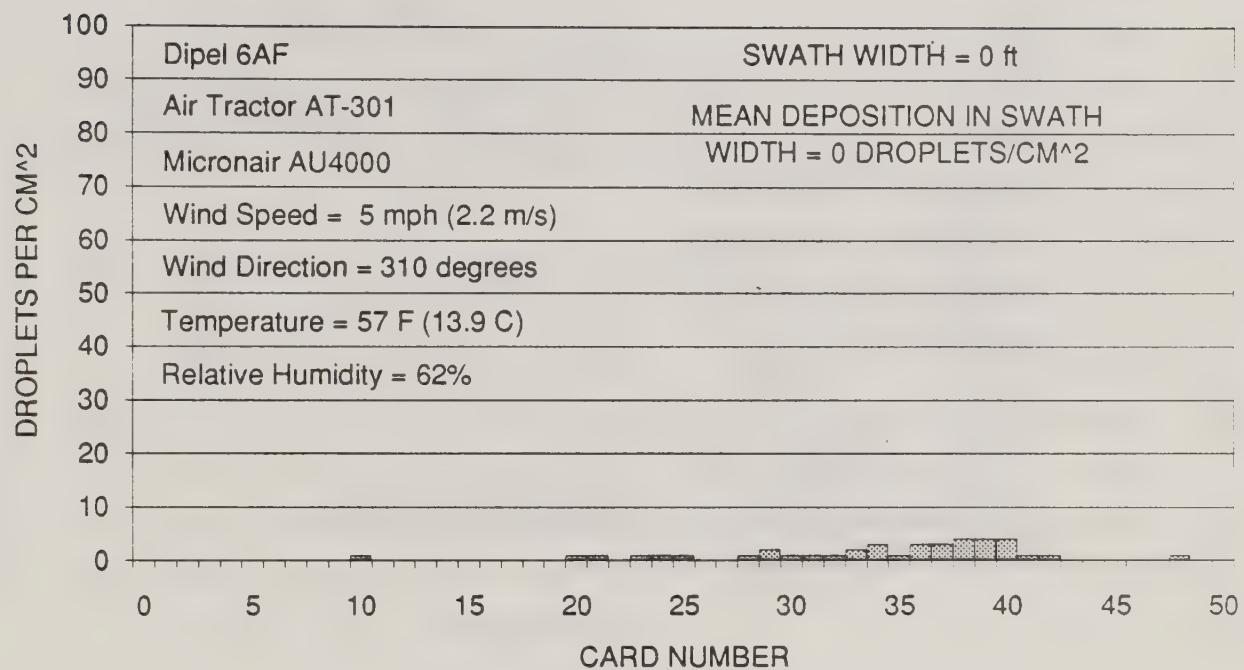
TRIAL 35 - STAKE TOP



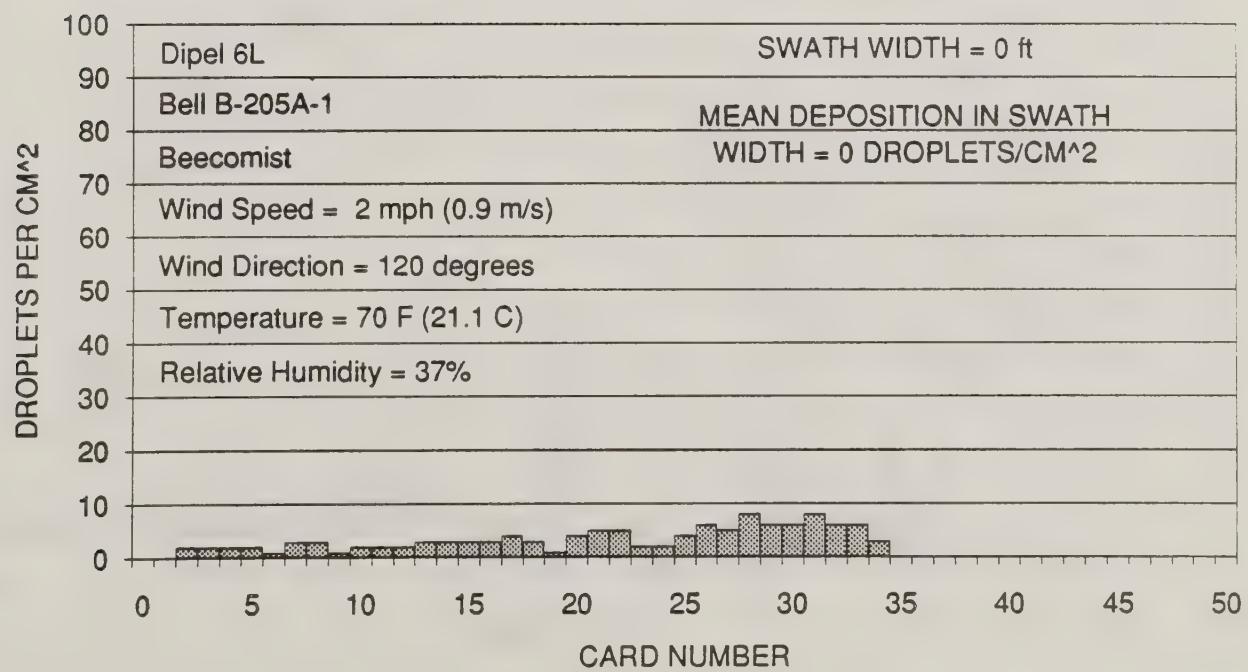
TRIAL 36 - STAKE TOP



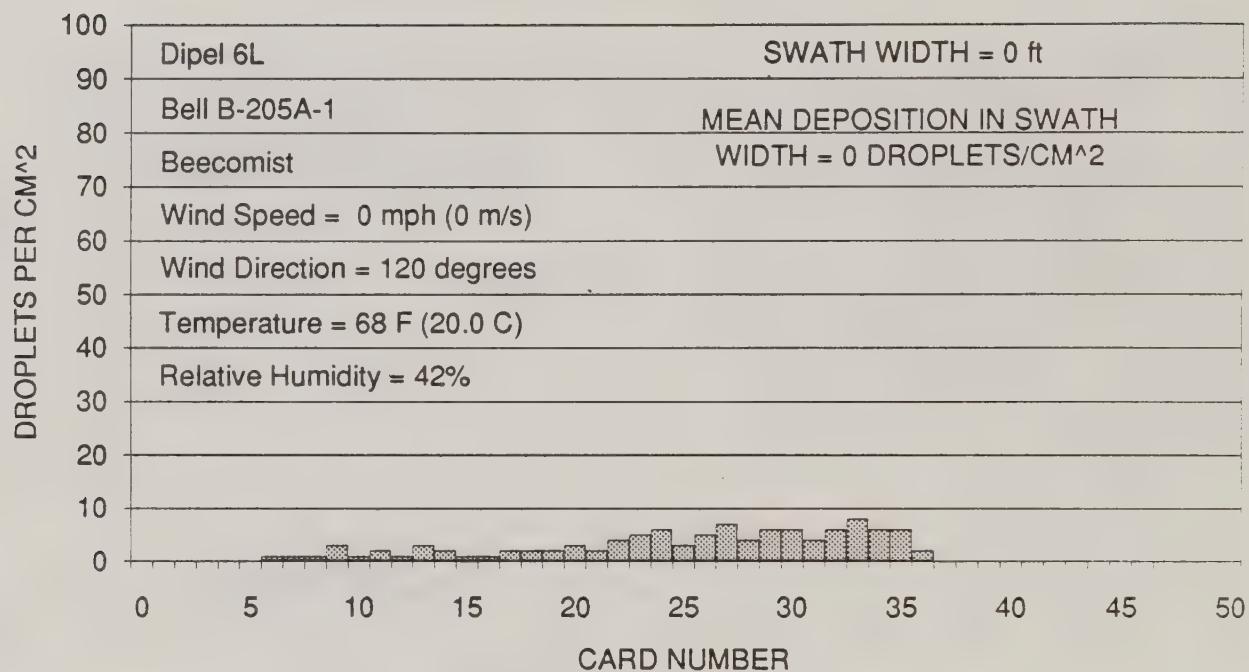
TRIAL 37 - STAKE TOP



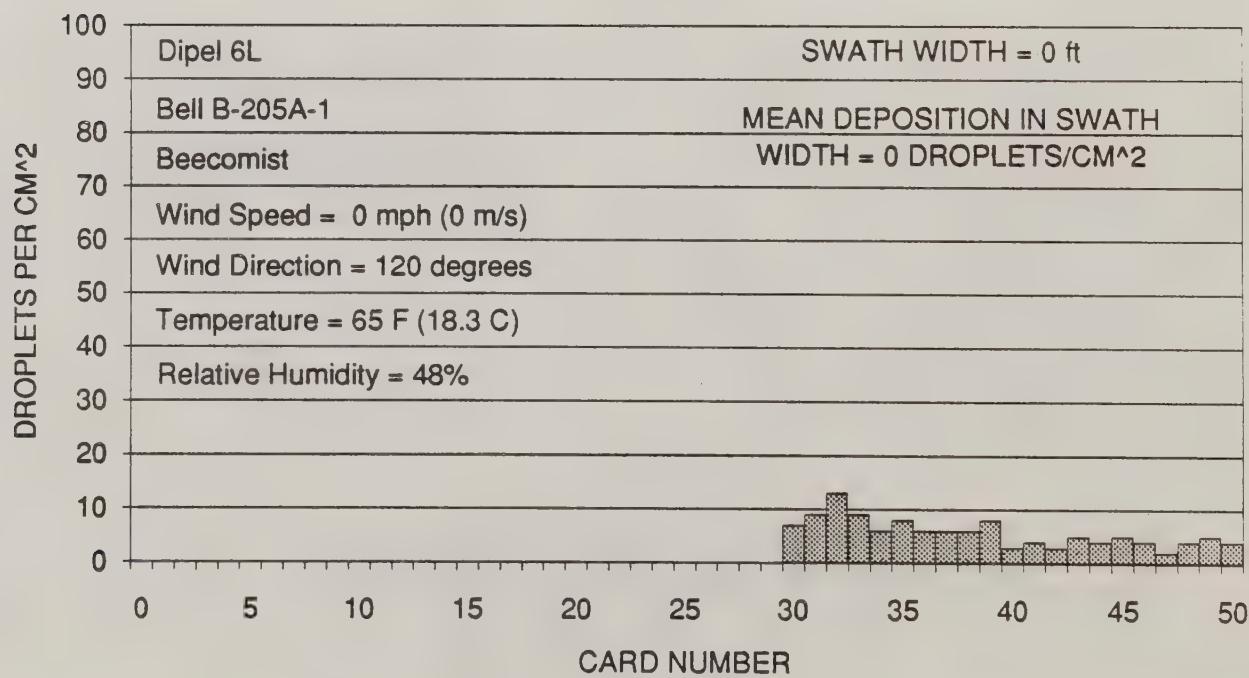
TRIAL 38 - STAKE TOP



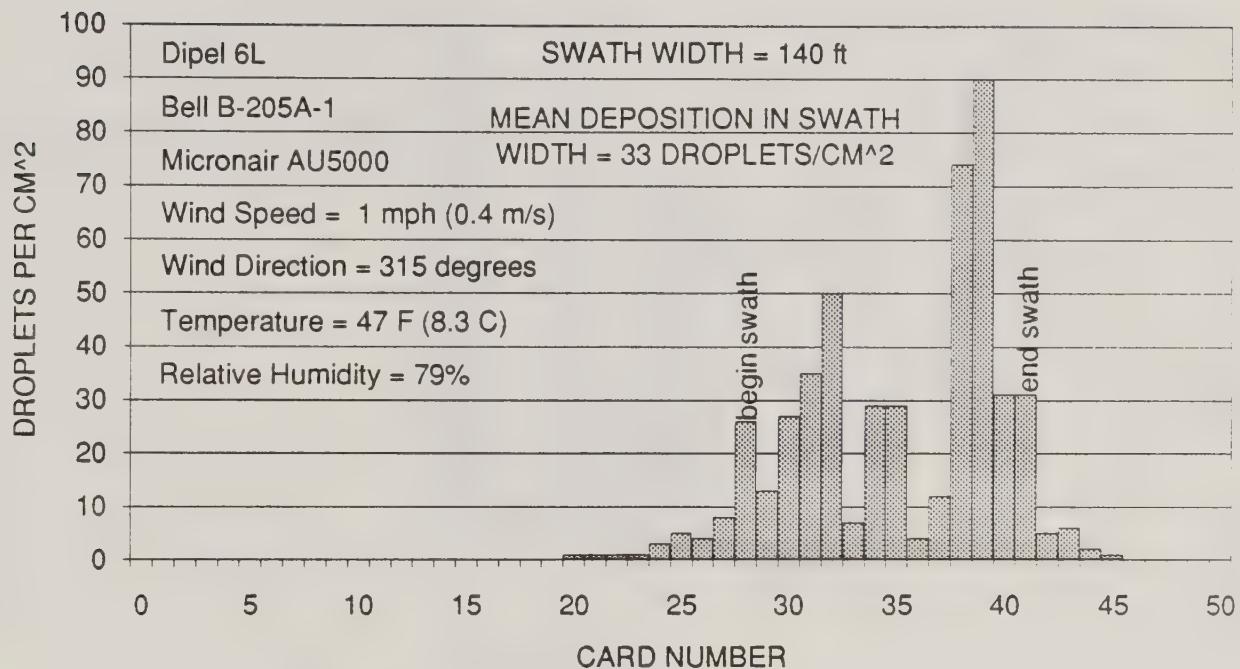
TRIAL 39 - STAKE TOP



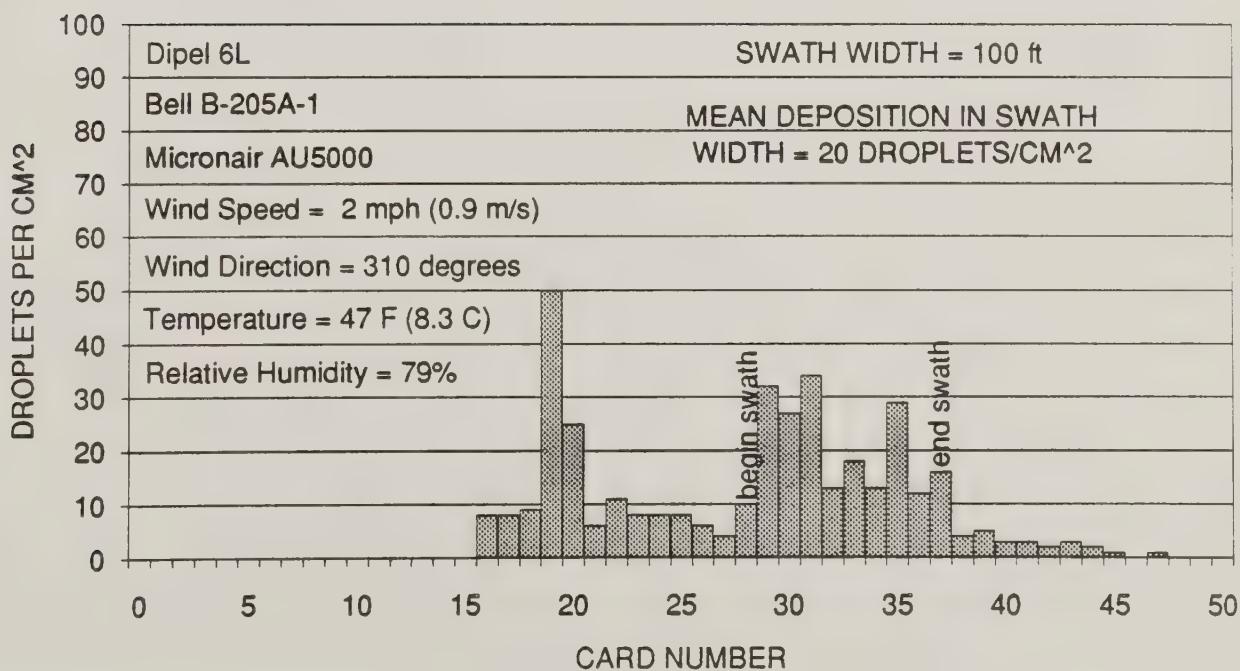
TRIAL 40 - STAKE TOP



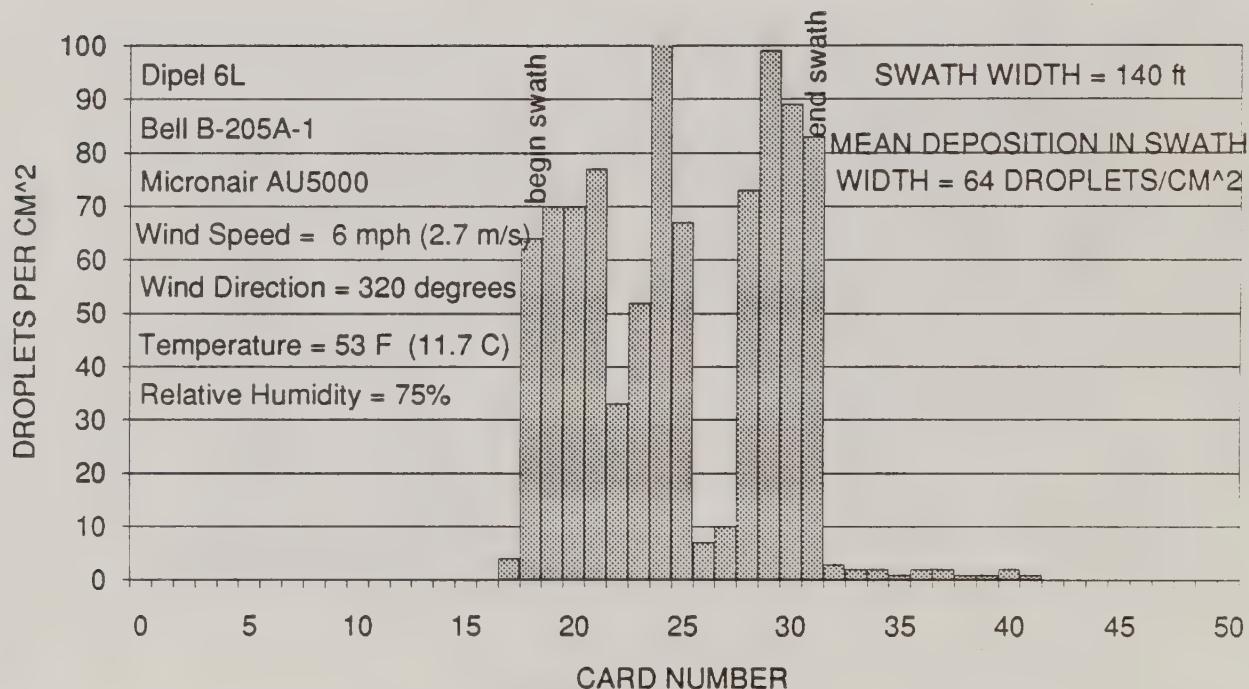
TRIAL 42 - STAKE TOP



TRIAL 43 - STAKE TOP



TRIAL 44 - STAKE TOP



APPENDIX C

Trial Data and Stake North Side Deposits in Tabular and Graphical Form

US FOREST SERVICE AIRCRAFT SPRAY CHARACTERIZATION TRIALS
MARCH 1988

Trial #	Chemical	Aircraft	Nozzle	SN1	SN2	SN3	SN4	SN5	SN6	SN7	SN8	SN9	SN10	SN11	SN12	SN13	SN14	SN15	SN16	SN17	SN18	SN19	SN20	SN21	SN22	SN23	SN24
1	DIPEL 6L	AT-301	AU4000	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
2	DIPEL 6L	AT-301	AU4000																								
3	DIPEL 6L	AT-301	AU4000	19	40	26	41	30	17	62	45	60	132	138	108	128	156	172	500	500	500	500	500	500	500	500	500
4	DIPEL 6AF	B-205	BEECOMIST																								
5	DIPEL 6L	AT-301	AU4000																								
6	DIPEL 6L	AT-301	AU4000																								
7	DIPEL 6L	AT-301	AU4000																								
8	DIPEL 6AF	B-205	BEECOMIST																								
9	DIPEL 6AF	B-205	BEECOMIST																								
10	DIPEL 6AF	B-205	BEECOMIST																								
11	DIPEL 6AF	AT-301	AU4000																								
12	DIPEL 6AF	AT-301	AU4000																								
13	DIPEL 6AF	AT-301	AU4000																								
14	DIPEL 6AF	AT-301	AU4000																								
15	DIPEL 6AF	AT-301	AU4000																								
16	DIPEL 6AF	AT-301	AU4000																								
17	THUR 48LV	B-205	BEECOMIST																								
18	THUR 48LV	B-205	BEECOMIST																								
19	THUR 48LV	B-205	BEECOMIST																								
20	THUR 48LV	B-205	BEECOMIST																								
21	THUR 48LV	B-201	BEECOMIST																								
22	THUR 48LV	AT-301	AU4000																								
23	THUR 48LV	AT-301	AU4000																								
24	THUR 48LV	AT-301	AU4000																								
25	THUR 32LV	B-205	BEECOMIST																								
26	THUR 32LV	B-205	BEECOMIST																								
27	THUR 32LV	AT-301	AU4000																								
28	THUR 32LV	AT-301	AU4000																								
29	THUR 32LV	AT-301	AU4000																								
30	THUR 32LV	AT-301	AU4000																								
31	THUR 32LV	AT-301	AU4000																								
32	THUR 32LV	AT-301	AU4000																								
33	THUR 32LV	AT-301	AU4000																								
34	DIPEL 6AF	AT-301	AU4000																								
35	DIPEL 6AF	AT-301	AU4000																								
36	DIPEL 6AF	AT-301	AU4000																								
37	DIPEL 6AF	AT-301	AU4000																								
38	DIPEL 6L	B-205	BEECOMIST																								
39	DIPEL 6L	B-205	BEECOMIST																								
40	DIPEL 6L	B-205	BEECOMIST																								
41	no	trial	#41																								
42	DIPEL 6L	B-205	AU5000																								
43	DIPEL 6L	B-205	AU5000																								
44	DIPEL 6L	B-205	AU5000																								
45	DIPEL 6L	B-205	AU5000																								

no stake cards

no state cards

SN25	SN26	SN27	SN28	SN29	SN30	SN31	SN32	SN33	SN34	SN35	SN36	SN37	SN38	SN39	SN40	SN41	SN42	SN43	SN44	SN45	SN46	SN47	SN48	SN49	SN50	Mean	Stdav	CV %	
25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50				
125	140	134	166	222	192	254	258	180	86	190	194	146	138	156	140	160	134	92	110	132	118	88	68	94	98	146	49.92	34	
500	500	136	124	88	52	20	22																			225	175.04	78	
500	500	74	66	50	18																					229	213.13	93	
22	22	80	90	54	28	98	140	130	110	90	96	84	86	70	76	78	74	70	54	68	72	68	20	38	41	73	30.06	41	
30	44	30	32	60	50	46	66	30	80	90	66	40	54	40	20	44	42	46	48	62	0	54	50	52	62	41	20.86	51	
14	14	20	14	12	18	26	30	21	30	37	42	76	73	34	49	50	35	36	51	52	57	49	41	53	50	38	17.44	46	
18	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	#N/A	#N/A	
						11	0	0	0	0	0	11														12	#N/A	#N/A	
23	39	16	22	18	22	11	13	12	22	11	10	11	13	12	0	12	10	12									9	6.56	73
0	29	13	15																							16	7.90	49	
																										24	14.16	59	
																										19	10.47	55	
																										15	4.32	29	
																										#N/A	#N/A	#N/A	
																										#N/A	#N/A	#N/A	
																										#N/A	#N/A	#N/A	
																										#N/A	#N/A	#N/A	
																										14	5.50	39	
																										10	9.24	92	
																										#N/A	#N/A	#N/A	
																										#N/A	#N/A	#N/A	
																										#N/A	#N/A	#N/A	
																										#N/A	#N/A	#N/A	
																										12	7.15	60	
																										#N/A	#N/A	#N/A	
																										#N/A	#N/A	#N/A	
																										60	23.04	38	
																										120	77.39	64	
																										32	13.61	43	
																										50	25.43	51	
																										20	7.95	39	
																										29	14.39	50	
																										11	2.12	19	
																										#N/A	#N/A	#N/A	
																										42	22.83	54	
																										22	5.73	26	
																										53	30.66	58	
																										NO	CARDS	#N/A	



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